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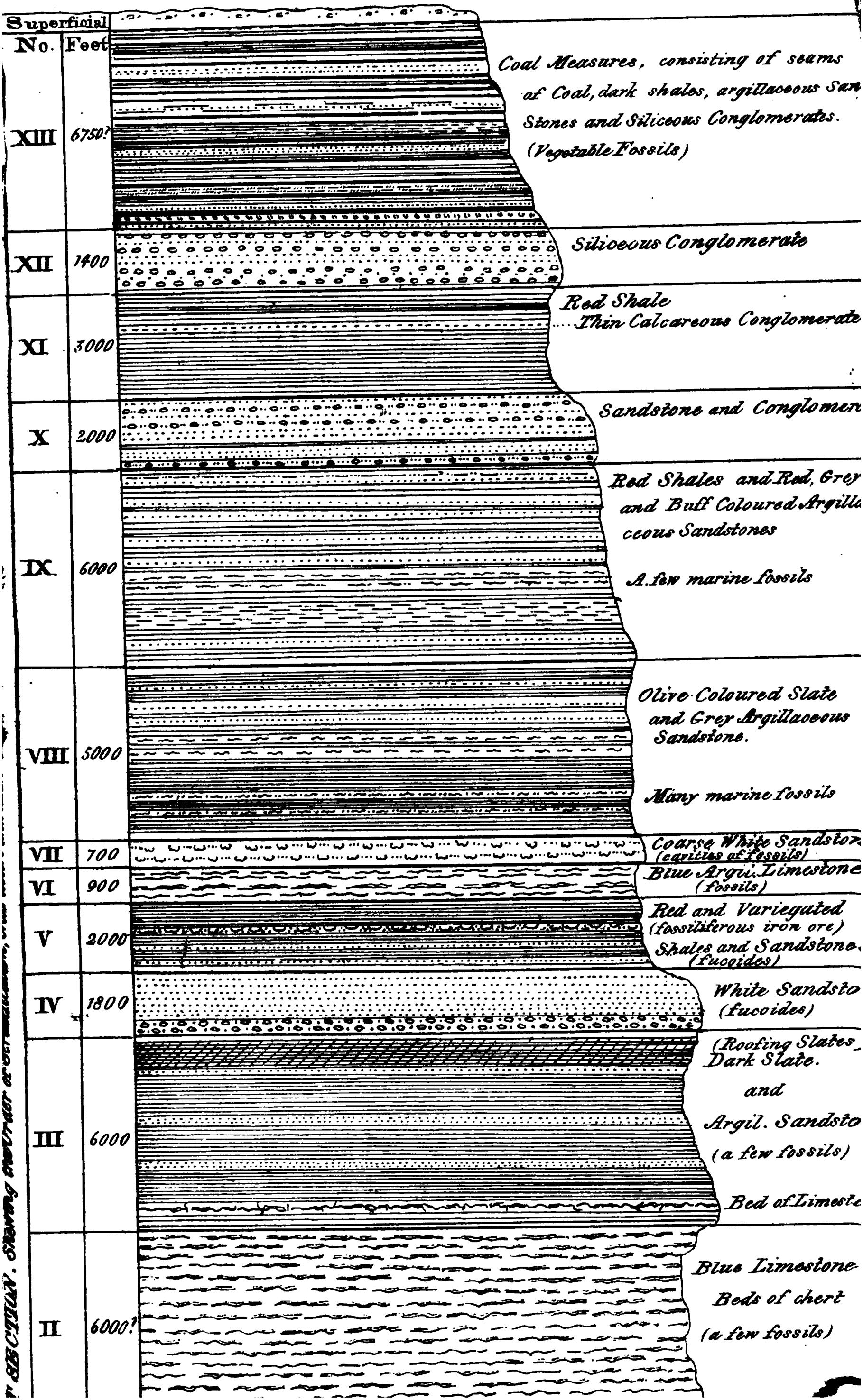
Superficial
No.
Feet
XIII
6750?
Coal Measures, consisting of seams of Coal, dark shales, argillaceous Sand Stones and Siliceous Conglomerates.
(Vegetable Fossils)
XII
1400
Siliceous Conglomerate
XI
3000
Red Shale
Thin Calcareous Conglomerate
X
2000
Sandstone and Conglomera
IX
6000
Red Shales and Red, Grey and Buff Coloured Argillaceous Sandstones
A few marine fossils
VIII
5000
Olive Coloured Slate and Grey Argillaceous Sandstone.
Many marine fossils
VII
700
Coarse White Sandstone
(cavities of fossils)
VI
900
Blue Argil. Limestone
(fossils)
V
2000
Red and Variegated
(fossiliferous iron ore)
Shales and Sandstone.
(fucoides)
IV
1800
White Sandsto
(fucoides)
III
6000
(Roofing Slates
Dark Slate.
and
Argil. Sandsto
(a few fossils)
Bed of Limeste
II
6000?
Blue Limestone
Beds of chert
(a few fossils)

SECOND ANNUAL REPORT

ON THE

GEOLOGICAL EXPLORATION

OF THE

STATE OF PENNSYLVANIA.

Geological survey
(1st, 1836-1841)

BY HENRY D. ROGERS,

PROFESSOR OF GEOLOGY AND MINERALOGY OF THE UNIVERSITY OF PENNSYLVANIA.

READ IN HOUSE OF REPRESENTATIVES, FEBRUARY 1, 1838.

HARRISBURG:

PRINTED BY PACKER, BARRETT AND PARKE.

1838.

SECRETARY'S OFFICE,
Harrisburg, Feb. 1, 1838.

To the Speaker of the House of Representatives:

SIR—In accordance with the acts of Assembly on the subject of a Geological Survey of the State, I herewith transmit the annual report of the State Geologist.

I am, Sir,
Very respectfully,
Your ob't serv't,
THO. H. BURROWES,
Secretary of the Commonwealth.

237522

REPORT

OF THE

STATE GEOLOGIST.

To the Secretary of the Commonwealth of Pennsylvania:

SIR—In compliance with my duty as State Geologist, I respectfully present to the Legislature, the following report of the progress which has been made in the Geological Survey of the State, during the past year.

In my former report, reasons were submitted somewhat at length, for excluding from my annual narrative of the operations of the survey, any detailed account of the facts ascertained during each season, and for presenting the whole of the results in one mass at the close of the survey, in the form of a comprehensive and properly matured description of the mineral resources of the State.

Another year's experience in conducting the work, with increased opportunities of intercourse with the people of the Commonwealth, have fully assured me, not only of the discreetness of the course adopted, but of its having met with the cordial acquiescence of our citizens.

I shall, therefore, in the present communication, after mentioning the districts of the State into which the survey has been carried during the past year, give a brief account of the mode of conducting the Geological examinations, and afterwards offer a short sketch of some of the general results obtained; abstaining as far as practicable from introducing, for reasons already before the public, the minute and local descriptions more appropriate to an advanced stage of the survey.

CHAPTER I.

OF THE SEAT OF THE OPERATIONS OF THE SURVEY.

The last Legislature having amended the act providing for the Geological Survey of the State by increasing the appropriation, with the view of adding two assistants, and of augmenting the fund set apart for the incidental expenses of the survey, it became my duty to make a new organization of the Geological corps upon the enlarged scale contemplated. Though solicitous to commence the active operations of the season with the full complement of assistants authorized by the act, it was found impracticable to embark with any increase of force beyond that of the former year; nor was it until the month of July, that after very diligent inquiry, I succeeded in supplying the survey with assistants of competent talents. The difficulty was in part occasioned by some unforeseen resignations, but more particularly, by the extreme scarcity at present felt every where throughout our country, of scientific persons of accurate knowledge and practical skill in the Geological profession.

I am happy to have it in my power to state that the survey is now supplied with the whole number of assistants authorized, namely, five; four of whom are aiding me in the Geological duties, and one in the Chemical analysis. Out of the fund designed for the incidental expenses of the survey, I was enabled during the latter half of the season, to secure the services of four additional aids, who acted in the capacity of sub-assistants; and who, by taking an active part in the collection of specimens, and in the numerous minute measurements required, have promoted very essentially the progress of the work.

The four Geological assistants are Messrs. SAMUEL S. HALDEMAN, ALEXANDER M'KINLEY, CHARLES B. TREGO and JAMES D. WHELPLEY, and the Chemical assistant is my brother, Dr. ROBERT E. ROGERS; all of whom merit a high encomium for the zeal and ability with which they have executed the often arduous duties which I have assigned to them.

The sub-assistants were Messrs. ALFRED F. DARLEY, EDWIN HALDEMAN, HORACE MOSES and PETER W. SHAEFFER; who likewise discharged their duty with much diligence, and a praiseworthy fidelity to the interests of the survey.

Notwithstanding the delay in getting the corps fully organized, it is believed a large amount of systematic and minute Geological research has been accomplished; for in consequence of the favorable character of the weather during the past autumn, operations in the field were actively prosecuted until the middle of November—a period later by several weeks than that which may occasionally terminate the season.

Through the zealous aid which I have received from the assistants and sub-assistants engaged in the survey, the observations made during this year, will be ultimately elucidated by a large and carefully selected series of characteristic specimens of our rocks, coals, ores and other minerals, exceeding probably Two Thousand pieces in number. These are now undergoing a minute examination, and receiving a temporary classification; such of them as require it, being set apart to be chemically analyzed or tested, preparatory to placing the whole collection, when the survey shall be sufficiently advanced, in the State Geological Cabinet.

It was contemplated in the early part of the season, to explore in more or less detail, all that portion of Pennsylvania included between the Delaware river from Easton to the New York line, on one side, and the Susquehanna from Middletown to Tioga Point, on the other, extending from the South Mountain to that part of the northern boundary of the State embraced between these two rivers. All the Anthracite coal regions and a wide circumjacent country would have been thus examined. Partly from the difficulty already referred to, of procuring adequate assistance at a sufficiently early period of the season, but more especially from the magnitude of the task itself, it soon became apparent that a portion only of this large territory could be minutely traversed; and this portion was further circumscribed by the time consumed in the detailed measurements which it became necessary to institute in exploring the several coal fields.

The investigations of the survey have been, during the past season, directed more particularly to the minute features of the several anthracite coal regions included within the general district allotted for examination. The great southern basin, lying chiefly within Schuylkill county, has received the most minute inspection; several portions of it having undergone as thorough an examination as the data supplied by the existing mines rendered practicable at the present time, though much remains yet to be seen before I can draw up a complete account of its resources, and explain the intricate features which these often present.

The most northern anthracite regions, those of the Wyoming and Lackawanna valleys, have in like manner undergone an extensive series of minute measurements, and have been explored somewhat in detail.

A less minute, though a still considerable degree of attention has been given to that part of the great middle coal region which lies between the head waters of the Little Schuylkill and the Lehigh rivers, including the Beaver Meadow, the Hazleton, and the several neighboring coal fields.

I am gratified to be able to state that though these researches in the several anthracite districts are, in consequence of the vast multiplicity of the points that needed examination, far from being terminated, they have already resulted in the development of facts of very high practical interest, calculated to lend greater certainty and expedition, in the discovery of coal in numerous new places, and to assist materially, it is hoped, by the sounder views which they may hereafter introduce concerning the structure of these basins, to the recovery of some of the coal seams, which from the nature of their dislocations, are daily deceiving the anticipations of the miner.

Much active capital is annually thrown away in our several coal regions, from a want of knowledge on the part of those interested, regarding certain features in the structure of particular parts of these basins, which cause many tracts that are externally promising, to be almost wholly unproductive. The survey, by making the true structure of these districts better known, has already done something, and will hereafter, it is believed, when the facts are ready to be published, effect much more, to check this waste of capital, and give it a more useful direction.

Some valuable and extensive deposits of iron ore, have been explored in the formations external to the coal regions, and such data collected concerning them, as must tend greatly to facilitate the development of the same ores in the corresponding formations in other districts of the State.

Besides the researches undertaken in the various Anthracite coal basins, a large extent of country, embracing the several formations below the coal, has been traversed, and in certain tracts minutely explored, where the nature and quantity of particular mineral deposits rendered such close attention necessary.

As many extensive districts, amounting in some counties to nearly their entire surface, possess a very simple, monotonous Geology, comprising only one or two well known formations, which were early ascertained to include but few valuable mineral substances, and those in very insignificant quantity, I have deemed it essential to the frugal use of the funds and time of the survey, to exercise a discretion as to the degree of minuteness of the exploration proper to each neighborhood. It is obvious that some quarters of the State, owing to the amount of their mineral productions, and to the intricate manner in which they are distributed, must require a far larger share of close and detailed investigation than other regions relatively barren in these resources; at the same time I would remark, that every section of the State will be examined with that degree of scrutiny necessary to determine the absence or existence, and the relative scarcity or abundance of those mineral deposits which possess a value from their useful applications. I mention this, because disappointment may otherwise be felt at no explorations having yet been made of particular places, containing, or supposed to contain, materials of practical importance. Many such places within the counties where the survey has been in progress, have not yet been explored; some from a conviction based on a previous familiarity with the formation, that they do not deserve the time it would require, and some in consequence of the investigations in the particular districts not having yet been terminated. I deem it necessary in Geological researches generally, for the sake of insuring accuracy, and for the avoidance of errors and omissions, that the explorer should revise many portions of his work, and make use of the fresh accessions of more and more exact knowledge which he is daily acquiring. Upon this principle, numerous districts, which some who are not familiar with the nature of Geological research, may fancy to have been superficially traversed, are designed to be again examined in certain portions, and under far more favorable circumstances for exactness in the results than could exist at first, when the materials appropriate to each formation had not as yet been ascertained.

The following sections of this report, describing the nature of some of the more refined operations of the survey, and a portion of the general results arrived at in the prosecution of the work, will convey a more just idea of the amount of investigation performed, and the degree of detail introduced into it, than could possibly be made known through a mere enumeration of the districts visited and explored.

CHAPTER II.

MODE OF CONDUCTING THE GEOLOGICAL INVESTIGATIONS.

I now proceed to describe concisely the manner in which the field operations of the Geological Survey have been conducted. Some brief statements on this subject may operate to dispel certain erroneous notions, which many entertain throughout the State, in regard to what is really within the reach of Geological research, and at the same time, inspire a deserved confidence in the precision, the variety and practical value of those results which are attainable.

The legitimate objects of a Geological Survey, the intention of which is general, and public utility, should consist, I conceive, in determining :—

First. The nature of the various rocks comprised in the region explored, and the mineral substances which they enclose.

Secondly. The extent of country which each species of rock and its associated minerals (or in technical language, each *formation*) occupies, delineating the limits of every such mineral area on some map of adequate size and accuracy.

Thirdly. In establishing the order of *superposition*, not only of all the several formations, considering each as a group comprising numerous strata, but also, of the multifarious sub-divisions, or beds, composing the respective formations; ascertaining, at the same time, the *thicknesses*, severally of each individual stratum and group of strata, more especially where there are materials of direct value, such as, coal, iron ores, or useful rocks, forming a part of the series.

Fourthly. In determining, for as great a multitude of places as possible, the angle and direction of the dip, (or slope) of the strata, in order to compute to what depth any known bed or layer descends below the surface in any particular neighborhood.

Fifthly. In ascertaining as nearly as possible, the *configuration of the surface*, so as to be able from observations made on the range, the thickness and the dip of the strata, to calculate, among other results, at what places on the surface, any regular mineral deposits that we may be tracing, will shew themselves.

Sixthly. In detecting and tracing those contortions, and those abrupt *dislocations* of the strata, which in so many rich mineral districts occur to frustrate the hopes, and to baffle the skill of the industrious miner.

An accurate knowledge of these irregularities in the Geological structure of a region, is only to be gathered from an inspection, both extensive and critical, of its mines, and from the features sometimes seen in the exposed portions of its surface. Every person, at all familiar with mining regions, will perceive the incalculable advantage to any disturbed mineral district, of this kind of knowledge regarding it.

SEVENTHLY. A judiciously conducted survey must of course include an examination of all those mineral substances, not regularly disposed in strata, but dispersed with less method either in the soil or the solid rocks; which from their properties and their quantity promise to be useful to society. The mode of tracing these materials is more desultory than that where the deposits are regularly stratified, and in the following account of the methods of examination adopted, little will be said regarding this branch of Geological research, as few rules can be laid down to assist investigation, where success depends chiefly on experience, guided by a knowledge of the principles of the science and of the Geology of the particular country to be explored.

In entering upon the detailed investigation of the country included between the Susquehanna and Delaware rivers, which was the principal theatre of the operations of the survey during the past year, a sufficiently correct, general knowledge of the formations of this part of the State had been previously acquired, to render it wholly unnecessary to make, (as was done in the previous season,) any reconnoisance of the region by crossing the country transversely to the range of the strata, a preliminary step of the greatest consequence when the general structure of a district is not already definitely known. A more minute species of exploration was therefore commenced early in the season. A triple sub-division of the whole region being made, the central portion, including all the Anthracite tracts of the State, was confided to two of the Geological assistants, but owing to the highly responsible nature of the researches, I devoted by far the largest share of my own personal labors and superintendence to this quarter. To another assistant was allotted the country laying north east, and north of the several Anthracite coal regions; while the fourth assistant, was charged with the examination of the section included between the south mountain and the blue mountain. From the comparative intricacy of the Geology of this last division, and from its abundant mineral resources in the shape of iron ores, roofing slates, limestone and other materials, I bestowed on it, next to the southern Anthracite region, the largest proportion of my time and personal study.

The north-eastern and northern counties of the quarter of the State, under investigation, being marked by great uniformity and simplicity of structure, and containing formations relatively less abundantly supplied with useful mineral substances, this division was conceived to claim for the present, a smaller share of my individual attention.

Throughout these several sub-divisions of the State, a very considerable progress has been made, in tracing the boundaries of each of the formations and in delineating them upon the map.

An ample collection of specimens, illustrating both the more immediately useful, and the scientifically interesting facts in the Geology of the region, was at the same time gathered. Mines, excavations of all kinds, and the natural exposures of the rocks and minerals were visited and explored, wherever any hope was entertained of their affording an insight into the resources and structure of the country in their neighborhood in regard to points not previously established.

The various investigations already alluded to as constituting the inquiries essential to a properly conducted Geological Survey, having been pursued with as much minuteness and method as was practicable amid the impediments arising from the gross defectiveness of the State map, from the wilderness condition of many parts of the regions explored, and the natural intricacy in the Geology of other portions of the country, it is unnecessary to dwell in detail, on all the methods resorted to for collecting the imformation sought. I deem it quite proper however, to call attention to the use made, in the operations of this year, of various kinds of surveying instruments, introduced for the purpose of imparting increased accuracy to many of the investigations.

To procure a correct knowledge of the actual position, and the true magnitude of the mineral deposits, as coal, certain kinds of iron ore, and other valuable beds composing part of the strata of any region, it is indispensible that numerous measurements be performed with the compass, or what is better, with the theodolite, the chain, the level, and the barometer, to astertain the thickness of each formation, and in some cases of each separate stratum.

In performing these measurements, the method is to select some spot, the neighborhood most usually of a stream, where the rocks are sufficiently exposed to display their numerous beds, with their dip or inclination to the horizon, and whatever other important features of stratification they may possess. The more nearly perpendicular to the course of the strata, the general direction is of such natural sections of the rocks, the less is the intricacy of the measurements, and the simpler are the calculations necessary to show the true place and thickness of each bed and formation in the series. It so results from the peculiar nature of the great subterranean movements which originally elevated our strata, and from the skill of man in constructing avenues of communication among our most rugged hills, that the mountainous districts of Pennsylvania offer the Geologist a remarkable variety of natural and artificial sections, singularly well adapted for supplying accurate data for Geological measurements, and for facilitating the collection of an ample and continuous series of specimens for illustrating our mineral resources. In many cases a stream passing out of one longitudinal valley to enter another parallel with it, flows through some notch by which the dividing chain of hills, or mountain ridge is cleft to its very base, while, as if to assist still better the researches of the survey, some road, canal, or rail road, stinted in room, has caused the aritificial excavation of the strata, hereby presenting the best conditions possible for accurately studying the rocks and their contents, for securing characteristic specimens, and at the same time for affording a *base* for measuring the position and dimensions of every thing contained in the formations.

A close examination of our rocks, performed with the aid of instruments, being thus very practicable at a great number of places, it is contemplated to multiply these minute operations of the survey, so as to extend them, not only to all the formations of the Appalachian region, but to many different places in each formation, for which there exists a peculiar facility on account of the reappearance at the surface of most of the strata in several successive belts as we cross the mountain chain of the State. This is likewise promoted by the many natural transverse sections which each formation presents wherever it re-emerges along a ridge or valley of any considerable length. Comparisons may thus be instituted of the highest practical and scientific importance between different portions of the same group of rocks as seen at various distant points. Thus—should it appear from measurements made of a particular formation in a certain county, that at a given number of feet from the top or bottom, it embraces a regularly stratified bed of iron ore, valued for its excellent properties, it becomes a point of deep interest to ascertain, even with an approximation to accuracy, the distance at which it is likely to be found from the top or bottom of the same formation, should it shew itself in other quarters of the State.

The whole stratum, from a number of examinations made at different points, is perhaps observed to undergo elsewhere, a regular increase or diminution in its thickness; but a chain of such observations will inform us of the *rate* of this change and enable us to judge with tolerable precision of the real situation of the bed of ore, should it still exist in the formation.

Convinced of the correctness of the views here expressed, in regard to the utility of measuring in detail the strata at various exposures, I planned and set on foot the instrumental survey of an extensive series of Geological sections, several of which have been elaborately executed, occupying with the necessary subsidiary explorations a considerable portion of the latter part of the season.

To present a rapid sketch of what has been done in this branch of research, in the several formations composing the region set apart for the past season's operations, it is proper, first to mention, that no suitable opportunity presented itself for attempting any detailed measurements of either the *sandstone* formation at the base of the whole series of our secondary rocks, which rests usually on the flanks and at the foot of the northern ridges of the South mountain, or of the great *Limestone* of the Kittatinny valley, the next stratum in the ascending order.

A minute examination with the aid of instruments, of the next rock, the *Slate* of the Kittatinny valley, was made on the Delaware river, from a point nearly opposite Columbia to the Water Gap; and the same measurements were extended to embrace a complete section of several of the overlying strata, the sandstones and conglomerates of the Kittatinny mountain, as they are displayed in the majestic cliffs of the Water Gap, and the shales and sandstones of the valley beyond it on the north.

A very extensive section has been begun but not completed on the Lehigh, commencing in the neighborhood of Mauch Chunk, with the conglomerate formation, which lies immediately below the coal measures and embracing all the several groups of strata so admirably exposed along the river fromthat point to the southern side of the bold notch by which the Lehigh passes through the Kittatinny mountain into the valley to the south. From this line alone, much useful knowledge will be derived. The measurements, and the specimens there collected, will shew the dimensions and composition in this section of the State, of all the strata, composing no less than nine out of the whole thirteen formations, which constitute the Appalachian region of Pennsylvania.

Another continuous section, including almost as large a number of the formations, eight in all, was measured along the east side of the Susquehanna river, starting from the southern base of the Kittatinny mountain, at the upper surface of the slate, or third formation of the series, and extending through Dauphin to the Third Mountain, to the top of the Eleventh rock in the series, or the red shale below the coal. A comparison of this section, with those made across the same belt of strata, at points further east in the State—for example, with that on the Lehigh above spoken of—will present some instructive points of contrast and resemblance.

A highly interesting exposure of the denuded edges of nearly all the middle formations of the series, being exhibited on the western side of the Susquehanna, between Catawissa and Bloomsburg, and extending by Fishing creek and its little tributary, Hemlock creek, into the heart of Montour's ridge, so as to lay bare nearly every stratum included between the lower part of the Fifth formation and the upper part of the Ninth, a line of measurements was here undertaken.

One principal motive for performing this, was to ascertain with precision, the place among the formations of the valuable layer of iron ore for which the neighbourhood in question has become somewhat noted. This section was made to terminate at the junction of Formations No. IX and No. X, at a point near the summit of the Catawissa Mountain; but in order to extend it to embrace the next superior group of rocks, a measurement of these was accomplished where the recent cuttings on the rail road, at its passage through the mountain in the gorge of the Catawissa creek, afford unusually great facilities for the purpose.

In order still more fully to establish a clue to the position of the band of iron ore above mentioned, and to ascertain its range and probable quantity, another shorter section confined to the formation immediately embracing it, was surveyed at a fine exposure of the stratification two and a half miles below Danville, in the cliffs called the Danville Narrows. The data furnished by these investigations, will serve, it is hoped, as an index to point out the position of this ore, and the indications by which it must be traced in the other counties of the Appalachian region of the State. The origin, chemical composition, and some of the Geological relations, thus ascertained, of this remarkable variety of iron ore, will be given in an after part of the present report, my present object being simply to exhibit the nature of some of the operations of the survey, and the principles and views which induce me to make them an important portion of the work.

In order to make known the true relative situation of the Anthracite coal measures of the State to the other formations which adjoin them, I caused a very complete section to be surveyed, and an ample collection of specimens to be gathered along the Schuylkill river, from near Mount Carbon, through the gaps in the Sharp and Second mountains, to a point within half a mile of Schuylkill Haven. From this section, that on the Lehigh below Mauch Chunk, and that on the Susquehanna near Dauphin, the relations of the Anthracite coal measures to the other formations, and of these to each other, will be satisfactorily seen; but until the proper time arrives for delineating them and the other sections of a similar kind, all of which it is intended hereafter to have engraved, it will be most judicious to omit attempting any minute account of them. With a view to establish in like manner the connection between the anthracite coal measures of the Wilkesbarre or Wyoming basin and the surrounding strata, and also to ascertain in what respects these differ in regard to thickness, composition, and mineral constituents from the strata of the same formations measured at the several points described, on the southern side of the Pottsville basin, a detailed survey was made of the rocks as they are exposed in the long natural section which the north branch of the Susquehanna displays in crossing the south-western point of the northern coal field at Beach Grove. Another was undertaken at the gap which the river makes at Nanticoke, and another at the gap of Salomn's creek, near Wilkesbarre.

Within the coal fields themselves, where such detailed measurements of the strata are of special importance for supplying the data by which particular coal seams may be traced and recognized, a number of complete transverse sections have been surveyed after the same plan. By far the most extensive and elaborate of these, and which has been performed with as much accuracy as the nature of the ground and the developments of the region would admit, embraces the entire width of the southern, or Pottsville basin, at its broadest part. This section, which is more than four and a half miles in length, extends from the Sharp mountain at Pottsville, to the southern slope of the Broad mountain, in a direction very nearly at right angles to the course or bearing of the strata. Wherever the strata along this line were found exposed by either natural or artificial denudation, direct measurements were made at right angles to their general bearing, and their dip or inclination carefully ascertained. The distances of the coal beds from certain fixed points, or from one another, were also obtained, either from actual inspection, or from data already in the hands of proprietors.

The same series of rocks and coal beds, whenever it was practicable, were visited and measured in several different places, in order to detect any changes which might occur in their relative thickness, and intervening distances. These measurements were then compared with each other, and the whole finally connected into one system.

In addition to the above labours, the coal mines were personally inspected, and observations recorded regarding their dip, direction, thickness, and the quality of the strata.

Sets of specimens were taken from each coal seam, both of the coal itself, and of its underlying and overlying strata.

Similar measurements, observations, and collections were made along a line crossing the coal region at Tamaqua, on the Little Schuylkill, the investigations here extending to a complete exploration of all the mines that are accessible.

Operations precisely analogous were performed in that part of the coal basin occupied by the Nesquehoning or Room Run mines, belonging to the Lehigh company and also at the vast excavations of coal called the Summit Mines, the property of the same corporation.

From the more backward state of development of the western half of the southern coal basin, fewer accurate measurements there were practicable. A transverse section of the basin on Rause creek, north of Pine Grove, was however surveyed, while many interesting facts, and valuable data concerning the coal seams and the iron ores of this portion of the region were procured.

The utility of a series of detailed measurements of our strata will be obvious, when it is considered, that in conducting such instrumental observations *all* the rocks and mineral deposits of a district, are in turn presented to inspection, so that the *true relative place* and *real dimensions* of the most obscure layer, if its nature justify it, may be definitely attained. Thus, when the measurements of a formation are sufficiently multiplied, *nothing* that constitutes a part of it as a regular stratum, however thin, need escape observation, since its place being already known in relation to that of all the other beds of the group, we are in possession of a clue of the least erring sort to lead us to its discovery. While this is strictly the case, let it be borne in mind, that the mineral deposits of the earth, unlike its vegetable and animal inhabitants, follow no very constant type, undergoing, though sometimes very gradually, incessant changes, both of composition and external features, so that it behooves us, before we apply in practice any supposed clue which our measurements may have afforded us, to assure ourselves, from an adequate number of instrumental observations, performed over a sufficiently wide district, of the nature and amount of the modifications presented by the strata, that we may make the required allowance in our calculations. Yet thisvery consideration is itself a striking argument in favor of the importance of accurately measuring our formations; for if they vary from point to point in their dimensions and aspect, how shall we guard against the liability of confounding one stratum with another, but by subjecting them at various places to that critical species of comparison which we may institute when we know all the dimensions and have full suites of specimens of the rocks before us. The propriety of this remark is well exemplified in the delusion, which many of the citizens of the State are under, respecting the presence of coal in a group of rocks in which it has no existence, situated several stages below the true coal measures, but where some fallacious appearances of a coal formation prevail. Some useful illustrations of the necessity of tracing the variations in the nature and quality of our rocks and minerals, by means of multiplied measurements, and an ample series of specimens will be offered in a subsequent part of this report.

While the examinations in the field have been thus in active progress, the investigations in the Chemical department of the survey, have also been diligently pursued.

A Laboratory has been provided with the requisite apparatus and agents, and an extensive series of Chemical analyses of the ores, coals, limestones, and other substances of practical importance which had been commenced towards the close of the former season, has been steadily prosecuted during the past year.

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I.	Southern margin of the Kittatinny valley, and northern side of the chain of hills called the South mountain.	A very compact, rather fine grained white and light grey sandstone.	Not ascertained, but probably 1,000 feet.

CHAPTER III.

AN OUTLINE OF THE GEOLOGICAL STRUCTURE AND MINERAL RESOURCES OF THE NORTH-EASTERN HALF OF THE APPALACHIAN REGION OF THE STATE.

The main intention of the present report being to exhibit a correct picture of the progress made in the Geological Survey of the State during the past year, that purpose would be imperfectly fulfilled, unless I added to the statement just given of the operations of the season, a brief general description of some of the more obvious Geological features of the regions explored. Such a sketch will serve the two-fold end of rendering more apparent the extent to which the survey has already proceeded in establishing many fundamental points in the geology of the State, and of placing before the reader a few of the results, whose useful applications will justify this early mention of them.

Having extended the investigations of the last season in greater or less detail, to all the formations lying between the northern base of the South mountain, and the table lands of the Allegheny mountain; and between the Delaware river from Easton to the northern line of the State, and the Susquehanna from Middletown to Northumberland, an opportunity has been afforded of becoming acquainted with the entire series of strata comprised in this north-eastern half of the Appalachian region of the State.

It will be seen by an inspection of the opposite table, that there are thirteen distinct groups of strata, or formations, in this portion of Pennsylvania, the lowest reposing on the primary or crystalline rocks of the South mountain, and the uppermost consisting of the materials embracing the anthracite coal.

In my first annual report of the formations occurring between the Kittatinny, or Cumberland valley, and the Allegheny mountain, and lying to the south-west of the Susquehanna, it will be remembered that only twelve were enumerated. But the researches therein mentioned did not extend to the formations of the Kittatinny valley, on the southern margin of which I have since found that another rock exists, underlying all those previously recognized which must now be added to the series. A comparison of the temporary classification proposed in the first report with that now offered, will present a want of agreement in two places. In the first place, the rocks described as third and fourth in the former series, are now thrown into one formation, and constitute the fourth of the present classification; and in the second place, the thick and conspicuous conglomerate and coarse sandstone rock which every where underlies both the anthracite and bituminous coal, is made a distinct formation from the coal measures with which I at first united it.

For the present I have studiously abstained from framing a nomenclature for the several formations of the extensive system of rocks here enumerated, preferring (until I become entirely familiar with the many modifications which they undergo in their course through the Appalachian region) to designate them as well by their numerical position, counting from the bottom of the group, as by distinctive features in the rocks, and a reference to their geographical situation. Until a very wide examination of the strata of our mountain series shall have been made, extending indeed to a comparison between the features they assume in our own and in the adjacent States through which they range, it would, I conceive, be premature to affix any other names to them than such as may hereafter be readily superseded. While our researches are pending, no mode of specifying the strata, appears so practically useful as that which expresses the relative situation of each rock to all the others of the region, and none certainly so free from ambiguity, when combined with a reference to their several geographical positions.

FORMATION No. I.

SANDSTONE OF THE SOUTH MOUNTAIN.

In the ascending order, the first formation which we meet with reposing on the primary rocks of the South mountain, (which is generally the south-eastern limit of the Appalachian strata of the State) is a remarkably compact and rather fine grained sandstone, usually white, or of some light shade of grey. It consists almost exclusively of nearly pure siliceous sand, held together, it would seem, rather by a simple, intense adhesion of the grains, than by the intervention of any cement. These grains, in some varieties of the rock, consist of nearly transparent quartz; in other instances numerous black crystalline specks abound, the fragments, apparently, of some of the harder dark minerals of the adjacent primary rocks, from the disintegration of which this formation has evidently derived its materials. Not unfrequently the stratum appears to have undergone a baking from great heat, as shewn by the approach to vitrification of the particles, by the fragmentary condition of the whole mass, by the ringing sound of the rock when struck, its splintery fracture, excessive hardness, and sometimes by a manifest discoloration, such as igneous agency is known to cause.

When thus partially altered, this rock is an extremely good material for roads, possessing the requisite durability, and yet on account of its shattered structure, demanding only a very moderate amount of labour to break it up.

The formation ranges, according to my present belief, from the Delaware, at Easton, more or less interruptedly across the State, to the Maryland line, pursuing an undulating irregular belt, coinciding with the northern and north-western side of the chain of hills most commonly called in this State, the South mountain, the prolongation of the Highlands of New-York, and of the Blue Ridge of Maryland and Virginia. Its usual place is at the base and upon the flanks of the hills, which form the immediate boundary on the south-east of the great Kittatinny valley; but owing to the quantity of loose materials lodged at the foot of this chain, this stratum is only occasionally exposed, rendering its exact course through the country difficult to trace and delineate upon the map. It is met with in a few places apart from the range of hills against which it commonly reposes, occuring even at distances of some miles in the Kittatinny valley, having been thrust to the surface through the thick overlying limestone formation by the agency of the vast subterranean forces which once convulsed this whole region. In these cases, it almost invariably gives evidence of having experienced an intense heating.

The formation is to be seen on the northern slope of the hill called Marble mountain, near Easton; also in a ridge about two miles east of Allentown, where it plainly exhibits changes of appearance, resulting from great heat, and a violent crushing force. It is seen at a point considerably nearer to the same town, where it has been somewhat extensively quarried to supply a building stone for the fine new bridge just erected over the river Lehigh. For such purposes it would seem to be extremely well adapted, whenever it can be found, as it often is, unchanged by the agency above alluded to. We meet with it again near Metztown; also, in a ridge near Coxtown, and in very regular stratification about three miles from Reading, well exposed by the cuttings on the Philadelphia and Reading Rail Road. Not to attempt at present tracing it in any detail, it may be enough to mention, that it occurs upheaved in a bold ridge at Chicques, on the Susquehanna, a mile and a half above Columbia, and at many points still further to the south-west—thus it is found in the same range at Ege's iron works, seven miles south of Carlisle, and at the gap of the South mountain, on the Chambersburg and Gettysburg turnpike.

The principal uses to which this rock is applicable, have been already mentioned; but I cannot avoid in this place calling attention once more to its fitness as a building stone, the more suitable varieties being sufficiently easy to quarry and to shape, undergoing no action from climate, and possessing, when dressed, a very agreeable light grey aspect.

Notwithstanding the occasional partial vitrification of this rock, at its junction with the primary masses against which it rests, the excessive compactness of structure arising from this source, though a common, is by no means a prevailing character. As soon as we recede from the immediate neighbourhood where the igneous agency is unequivocal, we find the sandstones to become less indurated, so that in many places its texture adapts it excellently for a building stone.

It contains, as far as yet examined in Pennsylvania, very few organic remains, the best defined species discovered in it being a marine plant, indicative of the oceanic position into which the materials of this stratum were originally swept.

I have satisfied myself that this rock is not confined to the Appalachian region of Pennsylvania, but that it possesses a prodigiously extensive range, not only through Maryland and Virginia, but in a contrary direction through New Jersey and New-York, and I believe beyond those limits, constituting every where the lowermost formation of the wide spread secondary strata which it encirles in a somewhat interrupted belt, following the primary boundary of these rocks from Tennessee to Lake Champlain, and thence north-westward to the northern shores of Lake Huron and Lake Superior.

I have undoubtedly recognized it at many points along the chain of the Highlands in New Jersey and New-York, and consider it identical with the formation which occurs in the north-eastern part of this latter State, and which was described several years since by Professor Eaton, under the name of "*calciferous sand rock.*" It is the same stratum, I am disposed to believe, which Dr. Bigsby has mentioned as existing on the northern side of Lake Huron.* My brother, Professor William B. Rogers, in conducting the Geological Survey of Virginia, has discovered the same formation there, resting upon the western slopes, of the Blue Ridge along which he has traced it for a very great distance.

FORMATION No. II.

LIMESTONE OF THE KITTATINNY VALLEY.

The next rock in the ascending order is the very extensive limestone formation which occupies the south-eastern half of the Kittatinny valley throughout its entire course across the State.

In its ordinary aspect this rock is a blue limestone, of a somewhat earthy texture, in general moderately pure, but often containing more or less sand, clay, and oxide of iron, alone or together, in its constitution. Layers of chert, sometimes called flint, are common between its beds. The direct superposition of this formation to the sandstone previously described, is well displayed in the excavation on the Philadelphia and Reading Rail Road, at the end of the Neversink mountain, three miles from the town of Reading. It may be seen in like manner at Chicques ridge on the Susquehanna.

At its south-eastern margin, or where it borders on the base of the South mountain, its general inclination is towards the north-west, in conformity with the dip of the underlying sandstone; but we seldom recede half a mile into the valley before a change of the dip to the south-east occurs, and what is not a little strange, this latter direction, though contrary to that into which we might naturally suppose the strata would be tilted by an upheaving action exerted along the chain of the South mountain, is by far the most prevalent inclination of this rock throughout its entire range. Between the Delaware and the Schuylkill there are frequently two, three, or more anticlinal axes, changing the direction of the dip of this Limestone though on its north-western margin, the inclination is towards the north-west, causing it to disappear in regular and orderly arrangement beneath the slate formation that next overlies it. But between the Schuylkill and the Susquehanna, a distance of fifty miles, these two formations observe a contrary or south-eastern dip along their line of contact, giving rise to the curious phenomenon of an *apparent inversion* of the strata; the slate, which was originally the uppermost rock, seeming to disappear beneath the beds of the Limestone which was originally undermost. From this circumstance, and the many indications of great fracture and contortion observable in the Limestone and slate of the Kittatinny valley, it would appear that these rocks are included in the most convulsed tract in all the Appalachian region of the State.

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* See transactions of the Geological Society of London.

The upheaving forces which have evidently disturbed the strata in various parts of this vast valley, have in several places thrust the subjacent Limestone to the surface within the district occupied by the slate. This is the case in the small isolated limestone tract on the west side of the Delaware, four miles below the Water Gap, the western termination of a long narrow *valley of elevation*, in which the Limestone is brought to view along the Paulinskill in New Jersey.

Another instance of the protrusion of the Limestone rock through the slate, is near Kreidersville, occurring, like the former case, in Northampton county, and a third is on the Little Swatara creek near Jonestown, in Lebanon county.

This truly valuable rock is applicable to many uses, some of them of the very highest importance to the prosperity of the section of the State possessing it.

In regard to the adaptation of the several varieties of this Limestone as a building stone, and to the manufacture of lime for mortar and cements, and for a manure for the soil, some interesting facts will hereafter be submitted when the results of the numerous chemical analysis, now on hand, are sufficiently matured to authorize their publication.

Omitting, for the present, the other topics that suggest themselves in regard to this rock, I may mention, as a matter worthy of present attention, the existence of highly ornamental marbles in various places throughout the formation.

Some very beautifully shaded and variegated marbles, capable of receiving a very fine polish, have, in the course of the past year been brought to light in Lancaster county by some of the inhabitants; and but little doubt is entertained, that quarries may, hereafter, be opened, which will yield slabs and blocks of adequate dimensions, to make these discoveries of considerable importance. It may be of use to mention here, that I consider the Limestone formation of the neighborhood of the city of Lancaster and the adjacent part of the country, to be the same rock as that which lies to the north-west of the South Mountain in Northampton, Lehigh, Berks, Lebanon and Dauphin, and that while a fairer prospect exists of meeting with the fine grained white and variegated kinds that constitute ornamental marble in the more altered part of the formation as it ranges through some portions of Lancaster county, yet sufficiently promising localities have already been explored in the other district to warrant a hope, a least, that marble of more or less excellent quality may be developed there. But numerous examinations and experiments are requisite to test the value of the specimens gathered, and time has not yet been afforded to enable me to report the results.

Iron Ores of the Kittatinny Valley.

The iron ore connected with the limestone formation of the south-eastern side of the Kittatinny valley, claims strongly our attention from its amazing quantity, its wide distribution, its generally very excellent quality, and its great accessibility.

Though very variable in external appearance and structure, this ore belongs universally to that species, called by mineralogists, *brown iron ore:* assuming nearly all of its modifications of form and structure. It is sometimes compact, and occasionally possesses a fibrous crystallization, and then is true brown *hematite;* but a more usual structure is either that of an irregularly cellular mass, or of a concretion composed of numerous parallel cylinders, like icicles or stalactites, in which case it receives the name of *pipe ore.* In chemical composition it is rather uniform, the more usual impurities being Silica, (the material of common sand,) Alumina, (or the material of pure clay,) and more rarely, Sulphur and Manganese.

The richer kinds may be stated to contain, on an average, from 70 to 80 per cent. of the peroxide of iron, equivalent to a little more than 50 per cent. of pure iron in the crude ore.

A few descriptive remarks, referring to two or three of the mines, will convey a sufficiently correct knowledge of the ordinary conditions under which it occurs.

On the north-western side of the Delaware river, about two and a half miles below Belvidere, a deposit of the ore exists, which is beginning to be somewhat extensively mined. It lies in a yellowish ferruginous clay, amid large detached pieces of limestone, but the diggings have not yet reached the regular strata of that rock. The chief deposit of the ore occurs about forty feet below the surface. In mining it, shafts are sunk until the ore is found, after which the excavation is carried forward horizontally in the ore, which is raised to the surfac- by a windlass. It consists principally of the porous cellular variety, and of the kind called pipe ore. An impure sandy ochre, and a fine white clay occur with it.

About five miles north-west of Allentown, and three from the river Lehigh, are large deposits of ore, which have been rather actively worked for the last ten or twelve years. The predominant variety here, is the brown hydrated peroxide of iron, though the red oxide is also abundant. True brown hematite, and a variety of jaspery iron ore, are likewise not uncommon. The material in which the ore is imbedded, is a ferruginous clay, resting over the limestone. A white clay, and an impure ochre are also associated as in the case below Belvidere. None of the excavations have yet reached the subjacent rock. The mining is done either by shafts, or when the configuration of the ground permits, by simply quarrying in the open air.

Iron ore is found in moderate abundance, and of excellent quality in the neighborhood of Emau's, five miles south-west of Allentown. It occurs in clay, no rock being very near it. The ore presents fewer varieties in this place than at the mines last mentioned.

About a mile and a half west of Trexlerstown, in Lehigh county, in a tract where the surface of the limestone formation is quite level, there is a very large deposit of iron ore, some of which, without altering its external structure, which is that of the cellular and pipe ores, has passed to the condition of sulphuret of iron, or the common *copperas mineral.* This mine was originally worked for the iron ore which it contains, this being still an object of pursuit; but the person conducting it, finding the good ore to be mixed with a large quantity of the sulphuret of iron, referred to me about three years since, to devise a remedy for the injurious effects of that material upon his ore and was advised to give his attention to it, not as an iron ore, but as a substance well suited for the manufacture of copperas. Since that time he has sold large quantities of it for this purpose, in Philadelphia, at seven dollars and a half the ton.

The several layers in this mine vary much in their dimensions; but their respective average thicknesses may be stated thus:

Soil	2	feet.
Brick clay, and gravel	25	"
White clay, pieces of slate, and red clay	3	"
Very dark clay	4	"
Iron ore and copperas mineral from 6 to 18 feet	12	"
Ferruginous sand	2	"
	48	feet.

Generally the pure iron ore, and the sulphuret of iron or copperas mineral, occur separately, or in different layers of the same stratum, the sulphuret in the lowest position.

The ore is of very good quality and of several varieties; among these, are the brown hydrated peroxide, having the forms of compact, cellular and columnar or pipe, ore; and the red hydrated peroxide, the structure and forms of which are no less diversified.

To attempt to specify in this place the very numerous localities in which the superficial appearances indicate the probable existence of more or less extensive deposits, or even to enumerate the many excavations, some of which are quite large, where the ore is daily procured, would be incompatible with the scope of the present report. It may not be amiss however, to mention one or two particulars respecting the manner in which it occurs.

It appears to be a general rule, that by far the largest and most numerous deposits of the ore belong to that half of the limestone belt which is next to the South Mountain. This is, however, not without exceptions, a signal instance occurring in the rich ore tract which lies about five miles north of Allentown, and a little west of the Lehigh, and which is but a short distance south of the northern margin of the Limestone at its junction with the slate.

No part of the whole limestone belt of the valley indicates the presence of so large a quantity of iron ore below the soil, as the district which lies a few miles south-west of Allentown, particularly in the vicinity of Trexlerstown. To allude to the circumstances which usually betoken an abundance of this kind of ore, one of the most obvious, would seem to be considerable depth for the deposit of ferruginous loam, clay, or other earth, resting on the rocks of the district. This will of course be marked by a corresponding evenness of the surface, for where the strata of the limestone are naked of soil in many places, it implies that the covering of earth which contains the ore can no where be deep. Another very essential condition is, that the earth overlying the rocks should have a large amount of the oxide of iron diffused throughout it. This will shew itself by its characteristic bright yellow, or yellowish brown, colour. It must be observed however, that the existence of a large quantity of oxide of iron in the deeper part of the soil, will very frequently not be perceptible in the colour of the surface of the ground, being confined to the lower layers, so that much good ore land is often neglected from want of enterprise to dig sufficiently deep.

The hydrated brown and red iron ores, of the principal limestone tracts of our State, I conceive to have originated almost entirely, from the filtration of water through deposits of soil rather richly impregnated with the particles of the peroxide of iron. This I think is proved, by the peculiar structure of the ore itself, which not only puts on the form of stalactites and stalagmites, (concretions of carbonate of lime, produced by the dripping of water,) but precisely those slight variations from these forms which ought to arise from the influence of the particular composition of the surrounding material,—clay or loam, or sand,—in modifying the manner in which the water would filter through the mass, and deposit the ferruginous particles.

The earth containing the ore, I suppose to have been a *sediment* from that mighty mass of waters which evidently once overspread all our formations, and which derived the materials of this deposit, if we judge by their nature, from the subjacent limestone and the contiguous sandstones. Thus we may at once discern why the largest and richest accumulations of iron ore, are on the side of the valley next the base of the South Mountain, for all independent Geological evidence concurs to shew, that the waters which I imagine to have left this deposit, flowed towards this quarter from the north, while the level of the valley being most depressed on this side, we ought naturally to look here for the deepest collections of the heavy ferruginous sediments in which the iron ore is principally found.

From the details above given of three or four of the ore deposits in Northampton and Lehigh counties, it appears that the richest collections of the mineral are at a considerable depth below the soil. Though in the cases already cited, the ore does not occur in contact with the underlying rock; instances could be brought from other quarters of the State, where rich masses, surrounded by the ferruginous loam of clay, lie in the spaces which often separate the disturbed and uptilted strata of the limestone near its surface. These facts, and the obvious origin of the ore by infiltration, suggest strongly the propriety of oftener seeking low down in the earthy deposit for the mineral, and of endeavouring to ascertain previously to commencing an excavation, whether the ground possesses that depth which would appear in general to accompany the larger accumulations of this valuable substance.

The earth resting on the limestone of the Kittatinny valley, contains in many places a variety of clay, admirably adapted for making bricks. The excellence of this brick earth is owing, in part, to the minutely divided condition, and the quantity, of its silica. This, intimately mixed with the argillaceous matter, imparts to the bricks great durability and uniformity of texture, while an adequate proportion of oxide of iron causes an agreeable and very permanent colour. The excellent hue and preservation of the bricks in some of the older houses in Easton, bear testimony to the good quality of the brick, earth of that particular neighborhood.

The remarks which I have here made concerning the great Limestone formation of the Kittatinny valley, have had more immediate reference to the rock as it presents itself between the Delaware and Susquehanna rivers, though they are scarcely less appropriate to other portions of its long range through the same extensive valley, which it pursues south-westward through this State, and Maryland and Virginia, and north-eastward through New Jersey and New-York, to the St. Lawrence. Throughout this whole course, it preserves invariably the same relative position to the long chain of mountains by which it is bounded on the south-east. It sometimes occupies nearly the entire width of the great Appalachian valley, but in general, especially to the north-east of the Potomac, it confines itself to the south-eastern side.

From Lake Champlain the course of the formation is towards the northern shores of Lake Huron, first encircling the elevated region of primary mountains in the north-east quarter of New-York, in a broad zone, the northern half of which passes up the St. Lawrence, while the other approaches, crosses, and again recrosses the Mohawk, passing Trenton Falls, and joining the first belt east of the outlet of Lake Ontario—whence its direction is nearly north-westward to the upper Lakes. In all this long line it accompanies our lowest sandstone, (the "calciferous sand rock" of Eaton,) overlying it, and like it, dipping commonly inwards from the border of the great basin, along the margin of which it ranges.

This formation is the same as that which, in my first annual report, I called the *Cove limestone*, from its composing a series of valleys in Bedford, Huntingdon and Centre counties, some of which are called Coves. But this name has too local a reference, and I propose to drop it, leaving the framing of a nomenclature for our rocks to a later stage of the survey.

In the Kittatinny valley, in this State, this limestone presents the explorer with very few well preserved organic remains, while it is replete with them at Trenton Falls, in New-York, and at several points in Virginia. Its fossils, however, are more abundant in the Limestone valleys on the north-western side of our Appalachian region. Well defined bivalve shells and zoophytes, characterize it in Morrison's Cove, Kishicoquillas, Nittanny and Nippenose valleys, and the several other valleys in the quarter of the State where this formation exists.

The largest Caves in the Atlantic States are in this formation, but this is not the place to speak of mere curiosities.

FORMATION No. III.

SLATE OF THE KITTATINNY VALLEY.

Ranging parallel with the great Limestone deposit just described, and lying next in order above it, occurs a not less extensive formation of *slate*, usually occupying the north-western half of the Kittatinny valley. These two very thick deposits throughout their whole course from the Delaware to the Susquehanna rivers, pass gradually into each other along their line of contact.

The upper beds of the Limestone partake of the structure and composition of the overlying slate, while the lower beds of this rock, are not only calcareous, but contain numerous distinct bands of moderately pure Limestone. These insulated narrow belts of limestone are subordinate to the slate, along nearly the whole of the central tract of the valley between the two great rivers, but they are most numerous north of the Tulpehocken creek. in Berks and Lebanon counties.

They constitute an important resource to the agriculture of the slate lands of all this range, in which the soil seems specially to require some assistance from lime, the judicious use of which liberally repays the farmer. These patches of limestone have, as far as time would permit, been carefully traced, and will be ultimately described in detail and delineated on the map. In its ordinary aspect and composition, the slate formation of the Kittatinny valley, which is the third rock in our series, does not differ essentially from the same stratum as it occurs around the margins of the limestone valleys and Coves of Bedford, Huntingdon, Centre and Mifflin counties, and which, in allusion to its usual situation, was called in my last report the *Cove Slate.* The ordinary colours of the rock are black, blue, dark grey, blueish grey, dingy olive, drab, and sometimes yellow; but in its range through the western part of Berks, and across Lebanon, its predominant colours are red, or reddish brown, with interstratified belts of yellow, the whole formation here assuming a considerable resemblance to the red and variegated slates of *Formation* No. V occurring north-west of the Blue mountain.

The formation as a whole varies extremely in the texture of its different strata, some of which are highly fissile slates, admirably adapted tomaking roofing and writing slates, while others are massive strata of coarse grey sandstone, with some thin beds of conglomerate.

That part of this formation which contains slate, adapted to the purposes of commerce, lies in a narrow zone, distant south, from one to three miles from the Kittatinny mountain, running from a point in New Jersey, a few miles east of the Delaware Water Gap, across the Delaware and the Lehigh, to a few miles west of the latter river. It is, however, only in a very limited number of places within this belt, that the rock presents that fortunate union of circumstances which must prevail to adapt it to be quarried with success. Not only must the rock be sound, uniform and compact in texture, easy to cleave in one direction, and tough in every other, and free from any bands (called ribbons) containing sulphuret of iron, which cause its rapid decomposition, but it must lie in a manner favourable for being quarried, with a stream of water passing over the stratum to preserve it moist, and thereby cause it to split with ease and regularity.

These conditions are found very happily combined in the two quarries, which are at present wrought near the Delaware Water Gap.—That on the west side of the Delaware, worked by the Pennsylvania Slate Company, presents some very interesting features. The true stratification of the rock is only detected here, by the difference in colour, caused by numerous very thin layers of from a few lines, to an inch or two in thickness, traversing the rock in lines parallel to each other and at various distances, not generally exceeding, I believe, two feet. These ribbons denote the direction of the dip of the strata, being seams of a somewhat different composition from the rest of the mass in which they were originally deposited at frequent intervals. Between each two of these ribbons the belt of slate is homogeneous, or of uniform texture and composition; but a difference in the quality of the slate on the two sides of one of these thin layers is quite common.

When we examine a new surface of the slate, the usual and permanent colour of which is a dark blueish grey, the hue of these ribbons is nearly black, but on exposure to the atmosphere, they shew after some time, signs of spontaneous decomposition, and display a whitish efflorescence, which indicates that this part of the slate contains the sulphuret of iron.

These ribbons are therefore carefully excluded from the slates when they undergo the operations of cleaving and trimming, in their preparation for the market.

At this quarry, the general dip of the strata, as indicated by that of the ribbons, is towards the west-north-west, at an angle of about 30 degrees, the exact course of the beds being north, 34 degrees east.—In the same part of the quarry the dip of the *cleavage planes*, or in other words, of the slates, is towards the *south*, and at an angle of nearly 50 degrees. There is, however, a dislocation or *fault*, traversing the quarry. This is a slide of one part of the stratum upon the other, and is from six to twelve inches wide, being filled with white calcareous spar and fragments of slate. That which is of chief importance, is, that the rock below it has not only a different actual dip from the portion of the stratum above it, just alluded to, and a different direction also in the cleavage of the slates, but a different quality in these slates themselves, those beneath being much superior to those over the dislocation. From this lower part of the quarry, nearly all of the roofing and writing slates are derived. The best school slates are got from belts that lie directly beneath the sparry seam or fault. The direction of the cleavage planes in this portion of the mass is nearly horizontal, while the planes of stratification dip towards the north-west, but at a very moderate angle. The discrepancy between the directions of the cleavage planes above, and below the fault, suggests the probability that the dislocation and slide in the stratum took place after the mass had acquired this remarkable tendency to cleave in a direction oblique to the stratification, for, had the cleavage originated subsequently to the disruption of the rock, we ought to find it maintaining the same direction, and observing the same features on both sides of the fault. These facts concerning the change in the quality and the position of the slates caused by the dislocation, indicate how numerous and minute the circumstances are which must be attended to by those who enter on the business of quarrying this rock. During the past year 13,500 dozen of school slates have been manufactured at this quarry, and somewhat more than 300 tons of roofing slates; but these amounts would have been much exceeded had not the general inactivity of commercial business operated to reduce the number of the workmen employed.

About a mile south-east of the quarry just described, another has been opened, but it has not been vigorously wrought. That on the opposite side of the river, in New Jersey, is worked, though rather inactively, notwithstanding the excellent quality of the roofing slates procured in it.

The only other considerable quarry at present in operation in the slate belt of this part of the State, is the Union Slate quarry, about one mile west of the Lehigh, and about seven miles north-west of Allentown. The most remarkable feature here, is the parallelism of the cleavage planes of the slates to the plane of the stratification. The dip is towards the south-south-east, at a somewhat variable angle, averaging 15 degrees. Owing to this coincidence of the cleavage with the stratification, the surface of the slates is apt to be slightly undulated. They are esteemed well adapted for roofing, but being hard, they are not sold for writing slates. The hardness of the rock in this quarry I attribute to the high temperature originally imparted to it by a mass of intruded quartz, which has entered it from a deep and heated source within the earth. This injected material has heaved up a portion of the strata into the form of a small anticlinal elevation in the quarry, and has in other respects deranged the dip of the rock. In 1836, there were sent from this quarry, by the Lehigh navigation, 500 tons of roofing slate, sold at eleven dollars the ton.

There is a small quarry which has been occasionally worked, lying about one mile and a half west of the town of Nazareth. Roofing slate was also formerly procured on the east side of the Lehigh, near Kreidersville, in Northampton county.

It is by no means improbable that other points along the same belt of country would reward diligent search by presenting eligible situations for quarries. A few such have yet been seen during the nvestigations of the survey, but more examination is required before any publication of the details would be appropriate.

One fact of some interest to those who may direct their attention to this slate tract is, that throughout nearly its whole course from the Delaware, to within a few miles of the Lehigh, the dip of the cleavage surfaces is towards the south east, and that too independently of the many contortions and changes of dip in the strata themselves of the slate and the adjoining formations.

In the neighborhood of Nazareth, which is on the line dividing the Slate from the Limestone formation, a material is procured, which answers well the ordinary purposes of *black paint*. This appears to be simply a more than usually carbonaceous, black and soft variety of the slate, occurring near the base of the formation a little above its contact with the Limestone. It occurs also further east on the Bushkill, and has been found likewise on the Union canal, in a corresponding situation in the stratum. It requires to be ground in a drug mill, and levigated in troughs by passing over it a stream of water. Thus prepared, it constitutes, when mixed with oil, a very excellent pigment for the exterior of houses, fences and other structures exposed to the weather.

Before closing these details respecting the slate formation of Pennsylvania, two facts of some practical importance deserve mention. One is, that this is the *same formation* which in Oswego county, in the State of New York, furnishes the grindstones for which that section of the country is noted, and which are distributed extensively throughout the Union. These come from near the Salmon river, about ten miles east of the town of Pulaski. The rock is a soft argillaceous sandstone, not unlike many of the softer sandstone beds of the formation in our own State. At several places in the Kittatinny valley, good grindstones are said indeed to have been procured.

It can hardly be doubted that the farmers and others residing upon the formation will find beds of this rock well adapted for making grindstones, if they will make some enterprising trials. Little skill or experience is necessary for testing whether the material is suitable.

The other fact that I would suggest relates to the identity of this formation, with that which extends along the Hudson river from Newburg, nearly to Glenn's Falls, and which furnishes a large supply of grey flag stones, not only to the city of New-York where the material is largely used in pavements, but to many other towns, and lately to Philadelphia. Though the strata of this formation in the Kittatinny valley are much contorted, and in many places greatly crushed, yet it is obvious that in so extended a range, numerous quarries of excellent flag stone, and, it is believed, of grindstone rock, might be successfully opened.

These suggestions are now made from a sense of the importance to our citizens, and to the public works of the State, of calling attention to many materials which we possess in abundance within our own borders, as the geology of our State plainly shews, but for which we have heretofore been sending to other States, and even to distant countries.

This slate formation of the Kittatinny valley though it extends in a *single* broad zone from the Delaware river to the western side of Cumberland county,.appears in Franklin county in two separate and wide belts, which run thence into Virginia. In its course across New Jersey it divides in like manner into two, and sometimes three, parallel ranges, separated by long narrow tracts of the subjacent limestone, which rises to the surface in the form of one or more anticlinal axes.

Before entering the State of New York these belts again unite, and constitute a very broad tract which occupies three-fourths, at least, of the great eastern valley of that State. Along the central and western portions of that valley, our slate formation ranges to a point somewhere east of Lake George, when coursing south-westwardly it shews itself on the Mohawk for many miles above its mouth, then doubles westward round the ridge of the Little Falls and extends in a north-western direction to the eastern shore of Lake Ontario. In this north-western part of its course, the strata are nearly horizontal, and contain, on the Salmon river, the beds already described as furnishing such an excellent material for grindstones.

In the first annual report on the Geological Survey of New York, the rocks of this formation occurring in that district are called "the grey sandstones and shales of the Salmon river."

Time has only permitted me to institute as yet a single detailed transverse measurement of the thickness of this formation, the results of which must for the present be accepted as only approximately correct in consequence of the obscurity of some of the exposures of the stratum. It was made on the west side of the Delaware river between the bottom of the sandstone of the Kittatinny mountain, (Formation No. IV,) at the Water Gap, and the upper surface of the Limestone, (Formation No. II,) exposed above Dills's Ferry. The thickness of Formation No. III, thus ascertained, is 6,102 feet.

FORMATION No. IV.

SANDSTONES AND CONGLOMERATES OF THE KITTATINNY, OR BLUE MOUNTAIN.

Overlying the great slate stratum above described, and dipping conformably with it, we find in the part of the State immediately referred to in the present report, a parallel formation consisting of heavily bedded sandstones and massive strata of conglomerates more conspicuous for the features they impart to the scenery, than for any considerable amount of practically useful material hitherto discovered to belong to them. These rocks are embraced in the long, narrow, nearly level, and generally single ridge, called the Kittatinny, or Blue Mountain, which stretches continuously from Cumberland county to within a few miles of the Hudson river near Kingston. They consist of massive strata of hard, white and grey, siliceous sandstones, of various degrees of coarseness, and also of ponderous beds of extremely hard quartzose conglomerate, the pebbles of which are often of great size. The finer grained sandstones abound most in the higher parts of the stratum and are identical in general aspect and texture, as indeed the whole of the deposit is, in relative position, with the stratum denominated in my former report, the *white fucoidal sandstone.* The main deposit of conglomerate lies at the base of the formation, resting upon the subjacent slate.

As a group of strata, the whole mass becomes progressively coarser and more varied in composition, as we follow it eastward from the Susquehanna. On the Lehigh and the Delaware it possesses but little of the fine and even texture, and the whiteness and pure siliceous composition which distinguish this rock as it occurs in the ridges in Bedford and Huntingdon counties, (in Tussey's mountain for example,) some portion of which it retains in the Kittatinny mountain near the Susquehanna.

Tracing it toward the Delaware it augments rapidly in thickness: at the Susquehanna this does not exceed about 400 feet, but at the water Gap of the Lehigh it is increased to 2000 feet at least.

Mixed with the quartzose sand and pebbles which constitute the principal mass of this rock, we encounter, especially in the coarse conglomerates near the bottom of the stratum, many rounded pebbles and fragments of the three underlying formations which intervene between it and the primary rocks at the bottom of the series. Thus we may recognize some of these pebbles to be derived from the lowest sandstone, some from the dark chert, or flint, so commonly imbedded in the strata of the great limestone, of the Kittatinny Valley, and others usually less regularly rounded, from the slates and grey sandstones of the extensive slate formation which these conglomerate strata immediately overlie.

Here then, we have an interesting proof that the materials composing this deposit were swept together by currents that were set in motion across the three lower formations which now occupy the Kittatinny Valley, whose strata were evidently at the same time more or less uptilted and crushed.

That great disturbances of the earth marked the period which closed the formation of the slate and accompanied the production of the overlying conglomerates and sandstones, is apparent from the coarseness of the ingredients in the latter rocks, the promiscuous manner in which they have been swept together, and especially from the suddenness of the transition between the fine grained slate, the sediment of very tranquil waters, and the extremely coarse conglomerate directly in contact with it, the whole aspect of which implies that an enormous mass of sand and gravel derived from strata just broken up, was suddenly strewed into the waters where the slate was forming. But if evidence still more unexceptionable be required of an upheave of the bed of the ancient ocean at the epoch immediately preceding the formation of these rocks, we have it, strikingly exhibited, at the north-eastern end of the formation, where these conglomerates and sandstones occur on the Delaware and Hudson canal near the end of the Shawungunk mountain. They are here displayed near Rondout, resting *unconformably* and with a gentle inclination upon the steeply uptilted, contorted, and disrupted strata of the immediately subjacent slate.

To suggest a useful application which may be made of some of the beds of the Kittatinny conglomerate, and at the same time to prove the importance, when exploring the mineral or geological resources of a region, of embracing as wide a range of observations as possible, I may state, that the somewhat noted Esopus millstones of New York are procured from the formation now before us. The stratum from which they are derived near the Delaware and Hudson canal, is one of the hard quartzose conglomerates in the Shawungunk mountain, which is the same ridge as the Kittatinny, or Blue mountain of Pennsylvania. There is a probability that in some of the several notches, or water gaps, of the Kittatinny mountain, a material may be found, as well fitted for making millstones, as the rock at Esopus. The researches hitherto made, regarding this point, indicate a sufficiently reasonable prospect of success to induce me to venture on the present suggestion.

The fourth formation of our series has a very extensive range.—Besides composing the entire mass of the Kittatinny mountain throughout its whole length, from the Hudson river to Cumberland county in our State, it forms the mountains nearly continuous with this range, which bound the Kittatinny valley, (or more appropriately the great *Appalachian valley*,) on the north-west, which extend through Franklin county, Maryland and the northern part of Virginia, and constitute many of the loftier ridges south-west of the Susquehanna, and between the line of the Kittatinny mountain and the base of the Allegheny. Though it terminates suddenly towards the north-east within a few miles of the Hudson, which it does not cross, the formation occurs in a district far to the west of this in the neighborhood of Utica, within a few miles south of which place, the stratum may be seen at several points, cropping to the surface with a gentle inclination towards the south-west. Here the total thickness of the formation does not probably exceed fifty feet, and yet in composition and appearance it is identical with the rock, as we behold it in the Kittatinny mountain near the Water Gap of the Delaware river.

The organic remains preserved in this formation are very few; those by which the rock can be most readily recognised by an uninitiated observer are certain species of *fucoides*, an extinct race of marine plants somewhat allied to the modern sea weeds. These are far more rare in the Kittatinny range of the formation than in the other belts of the stratum in the ridges in Bedford, Huntingdon, Centre, Mifflin and Juniata counties. I have, however, seen some broad surfaces of the rock at the Delaware Water Gap, covered by their interlaced and curving stems. This fossil not being confined to the formation under consideration, but abounding even more generally, both in this State and in New York in the lower beds of the next overlying deposit, I have discarded the name *fucoidal sandstone*, bestowed on it in my former report, as not sufficiently distinctive.

There is a small and very globose bivalve marine shell, a species of *terebratula*, which is occasionally met with in the finer grained sandstone layers very near the top of the stratum, and which I have seen as yet in no other rock of our whole group. As far as organic remains apply, this fossil is very characteristic of the formation.

FORMATION No. V.

RED AND VARIEGATED SANDSTONES AND SHALES OF THE VALLEY NORTH-WEST OF THE KITTATINNY MOUNTAIN, AND OF MONTOUR'S RIDGE.

Resting on the previously described sandstones of the Kittatinny mountain, and occupying a narrow belt of country along the north-western base of that ridge, a formation occurs, some of the characteristics of which are very interesting. This rock, which in my last report, I denominated the "variegated calcareous shale formation," when referring to the features which it assumes in the counties of the Appalachian region south west of the Susquehanna, is composed where it occurs in the belt next the Kittatinny mountain, of an uniformly red and slightly calcareous shale, and a more or less argillaceous red sandstone. It agrees very nearly in its ingredients, its red colour and other characters, with the lower division of the more variegated belts of the same deposit which are exposed on the Juniata river, but it is destitute of the many-coloured calcareous shales, and the numerous interposed layers of limestone that occupy the higher part of the mass in that quarter of the State.

These limestone layers have been sought for along the north-western base of the Blue mountain, in that part of the formation most nearly corresponding to their usual position, but they appear to be absent from this southeastern belt. The valuable, and somewhat remarkable, variety of calcareous iron ore which belongs to several of the tracts of the formation in other sections of the State, has been carefully sought in the same range, on the north side of the Blue mountain, and the conviction has arisen that it also does not occur. A description of this ore will be given when I come presently to speak of the features of the formation, on the North Branch of the Susquehanna: in the meanwhile, a brief mention of the range of the less important belt before us will be proper.

It follows the Kittatinny mountain along a narrow valley, usually not more than a mile wide, and often less, lying between the northern foot of the mountain and a low sandstone ridge, and extends thus from Perry county, nearly to the Delaware Water Gap. Its course thence, is in the same direction across New Jersey and New-York, to its termination a few miles south-west of the end of the Shawungunk mountain. It seems there to thin out and disappear, for it certainly does not cross the Hudson.

The red and variegated sandstones described in the first annual report, on the Geological Survey of New York, and which underlie nearly all the range of counties running westward, from Oneida county, to the Niagara river, belong to the same formation, and bear a very striking resemblance to the strata as they are displayed in our own State.

In the portion of the Appalachian region north-east of the Susquehanna river, and its West Branch, there are but two zones of this Fifth formation; the south-eastern one I have spoken of; the other, which lies in Columbia county, offers some features to which I now direct attention.

The belt now alluded to, occurs along the northern and southern slopes, and ascends in many places to the summit, of a long, narrow, and moderately high hill, which bears the name of Montour's ridge, and which commencing near the West Branch of the Susquehanna, about five miles north of Northumberland, runs nearly due eastward until it meets the bend in the North Branch of the Susquehanna, about two miles below Danville. Thence after curving for several miles a little to the north, the formation extends, steadily declining in altitude, until its strata sink away in a long and low axis, under the overlying formations, about four miles northeast of the town of Bloomsburg.

Throughout this range the beds are very regularly upheaved along a central line, or anticlinal axis, folding over the ridge and resting on its two flanks, with a moderate inclination towards the north and south, rarely exceeding from 15 to 25 degrees.

The lower strata alternate, as they do along the northern base of the Blue mountain, with the uppermost layers of the white and grey sandstones of Formation No. IV. retaining their characteristic chocolate red colour, and distinguished by the profusion of the impressions of *fucoides* upon their surfaces.

In these features they agree with the similarly situated beds, seen at the Lehigh Water Gap, at the Long Narrows on the Juniata below Lewistown, and at various other points throughout the districts where the strata at the base of the formation are exposed.

These may be examined at the southern foot of Montour's ridge, in some deep ravines cut by the streams entering the river near the "Narrows," about two miles below Danville, and in like manner in several places at the gorges of Fishing and Mahoning creeks, in the same ridge.

Above these lower beds, on both sides of the ridge, and also towards its eastern termination, where it is less elevated and steep, there is a rather thick stratum of dull olive coloured and yellowish brown slate, of a more or less sandy texture. Towards its upper part, occur some highly calcareous fossiliferous layers, from a few inches to a foot in thickness, and an interesting bed of iron ore to be presently described. In the upper part of this slate, there are a few calcareous fossiliferous layers, from ten to fifteen inches in thickness, constituting indeed a moderately pure limestone, with thin veins of white calcareous spar.

Over these, there reposes a heavy stratum of *red shale*, usually a little calcareous, and also, slightly siliceous in its composition, its ordinary character, however, being that of a thinly laminated and highly argillaceous rock. Its lower portion includes a few alternating bands of a yellowish green shale, but the upper part is more uniformly red or reddish brown. Towards the top of the stratum, this red shale passes into the next superior formation, (the limestone, which occupies the sixth place in our series,) by numerous layers of dull greenish yellow slates and calcareous shales, which grow more calcareous as they approach the limestone.

The somewhat noted and much prized calcareous iron ore of the formation before us, is merely one of the first mentioned calcareous fossiliferous layers, among the particles of which, the peroxide of iron, which has filtered from the adjoining ferruginous bands of the rock, is copiously disseminated, having taken the place, sometimes in part, sometimes entirely, of the carbonate of lime of the fossils, which has been dissolved out by the same process that has introduced the oxide of iron. This bed of ore occurs in two lines, one on the northern, the other on the southern slope of Montour's ridge and its prolongation to the east of Bloomsburg, dipping regularly with the other strata from the anticlinal axis.—Towards the eastern end of their range these two deposits, after converging and sometimes uniting on the top of the ridge, lose themselves under the red shales of the upper portion of the formation, in the vicinity of Espytown, but going westward they are traceable to a point a little west of Danville. The ore has not yet been discovered, at any considerable distance beyond this point.

The bed varies in thickness from six inches to two feet, and is not more uniform in the proportion of its oxide of iron.

In some places it seems to thin away entirely, in others, the bed divides into smaller layers which sometimes lose themselves in the contiguous slates. The ore is at present procured in largest quantity from the neighborhood of Hemlock creek, two miles west of Fishing creek, being mined on both sides of the stream, and also on both sides of the anticlinal axis in the northern and southern dipping strata of the ridge. East of Fishing creek, it has not yet been much developed. As far west as Mahoning creek, near Danville, a distance of about twelve miles from Fishing creek, indications of the ore present themselves on both sides of the ridge, though but few excavations have been made in the intermediate tract, owing to the ore here, being more remote from the canal than that on Hemlock and Fishing creeks.

The ore varies materially in different parts of the bed as respects its hardness, composition, and the proportion of its oxide of iron. The purer specimens consist almost exclusively of the per-oxide of iron and the carbonate of lime; these materials presenting the forms and impressions of the various fossils characteristic of the formation.

The siliceous and argillaceous ingredients rarely amount to more than fifteen per cent of the mass. The carbonate of lime can scarcely be viewed as an impurity, for this material under some form, usually that of crude limestone, is required in smelting nearly all the ores of iron. In this ore it exists disseminated, and in the most favorable condition of admixture to act as a flux; so that it must be regarded rather as a useful, than a hurtful constituent. It may be stated as a common occurrence, that near the surface of the ground, and for some yards below the immediate out-crop of the bed, the ore, in consequence of the prolonged action of water, trickling through it, and dissolving out its carbonate of lime, is generally soft and of a cellular structure, which is pronounced by those who make use of it to be highly favorable to its ready reduction in the furnace. That which is derived from a greater depth possesses much more compactness, and is both more difficult to be mined, and less rich in iron; and though imbued with a larger amount of the carbonate of lime, serving for a flux, it is by virtue of its greater compactness, less easily converted into the metal. The probability is, that by mixing the two varieties and using a copious blast, more economical and productive results will be procured than by employing even the richest kind separately.

In excavating the ore, that nearest the out-crop is reached by removing the covering of earth and slate to the depth of a few feet, while the portion lying further beneath the surface, is mined by drifts, or levels, entering the bed at points where some cross valley or ravine gives access to the ends of the strata. The band of ore is penetrated in the direction of its range, or parallel with the course of the stratum in which it lies, with just sufficient deviation from the horizontal line to drain the water from the mine, towards the mouth of the drift. It will become necessary, I apprehend, in order to get access to the ore in some of the middle portions of the belt when it cannot be reached by the mode of mining just described, to approach it by tunnels perforating the overlying strata. This method however, will be found much more expensive in the outset than the present plan by drifts entering at the notches, or depressions in the ridge.

Several points will require to be carefully considered by those who undertake to mine this ore, all of which are embraced in the question, of the depth, beneath its out-crop, to which the stratum may be profitably pursued. Upon this will depend the value of the belts of land along both slopes of the ridge below the northern and southern out-crops of the ore bed. One consideration, limiting the depth to which it can be advantageously worked, is the increasing hardness of the ore as we descend. Another is the seemingly progressive reduction in its richness by reason of the less extensive infiltration of the oxide of iron. And a third is the increased height through which the ore and the water will require to be lifted, whenever the mines shall be carried below the common water level of the country. The daily growing experience derived from the mining operations now on foot, will tend to multiply the data for making a safe estimate of the exact extent to which the buried treasures of Montour's ridge can be pursued. Enough is already known respecting the excellent quality of the ore, the large quantity still readily accessible, and the cheapness of the present modes of mining it, to establish a just confidence in the value of this formation as one of the choicest ore tracts in the State.

There are four furnaces which rely on the two or three mines at present in existence on Hemlock creek, for their main supplies of this ore; two are within seven miles of the ore bed, one is at Berwick, within about twenty miles, but convenient to the canal, and the fourth is at Farrandsville, in Lycoming county, to which the mineral is transported on the State canals, a distance of one hundred miles, thus affording a strong proof of the high estimation in which this ore is held.

An average specimen of the porous variety taken from the out-crop of the north dipping bed, on the west side of Hemlock creek, afforded on chemical analysis the following composition:

Analysis of the porous variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of Iron - - - - - - -	85.10	per cent.
Silica - - - - - - - - - -	7.10	"
Alumina - - - - - - - - -	5.00	"
Water - - - - - - - - - -	2.10	"
Lime and Carbonic Acid	a mere trace.	
	99.60	

The proportion of *pure iron* in this specimen, is very nearly 60 *per cent.* and it exists almost exclusively in the condition of the Peroxide.

Another specimen selected as representing the average quality of the ore in the lowest levels opened, taken at a depth of about twenty yards below the out-crop was in like manner analysed and exhibits the following results:

Analysis of the compact variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of Iron - - - - - - -	61.30	per cent.
Silica - - - - - - - - -	2.80	"
Alumina - - - - -	a mere trace	
Lime - - - - - - - - -	17.84	"
Carbonic Acid - - - - - - -	15.33	"
Water - - - - - - - -	2.20	"
	99.47	

The proportion of pure iron in this specimen, is about 43 *per cent* the condition in which it exists being that of the Peroxide combined with a small amount of the Protoxide.

With good management it is found that two tons of the ore on Hemlock creek will yield one ton of excellent cast iron, and I have been informed by a proprietor of one of the furnaces using it, that the result is occasionally even somewhat greater.

A section has been elaborately surveyed from the anticlinal axis in Formation No. V. on Hemlock creek, southward, across it and the other overlying formations, as far as the Cattawissa mountain.

Another measured in the narrows below Danville, starting from the upper beds of Formation No. IV. in the flank of Montour's ridge, and crossing Formations No. IV. and No. V. will in conjunction with the first, convey much detailed information respecting the modifications which the strata of this district undergo. They will prove especially useful, by designating the precise position of the iron ore of Formation No. IV. and by exhibiting the character and position of the several rocks both below and above it, every one of which will thus become, when carefully studied, an index to the same kind of ore in other quarters of the State. Upon this section the vertical thicknesses of the formations are as follows:

From the anticlinal axis on Hemlock creek, to Cattawissa mountain.

FEET.		
304.01	from	anticlinal axis to iron ore.
257.68	"	iron ore to red shale.
1372.66	"	commencement of red shale to limestone No. VI.
1934.35	"	anticlinal axis to limestone.
981.56	thickness	of limestone No. VI.
4471.59	"	of slates, shales and sandstones. No. VIII.
258.48	"	of alternating beds between No. VIII. and IX.
4172.35	"	of shales and sandstones of No. IX.

FORMATION NO. VI.

BLUE LIMESTONE ALONG THE NORTHERN BASE OF THE KITTATINNY MOUNTAIN AND ALONG BOTH SIDES OF MONTOUR'S RIDGE.

The rock which occupies the next place in the series, is a blue Limestone. In those tracts where it is fully developed, it consists of several distinct strata which differ from each other in colour and texture, some of them being remarkable for the variety and the profusion of their fossils.

Between the base of this formation and the upper portion of the immediately underlying "red and variegated sandstone" formation, a somewhat gradual mingling of the characters of the two respective rocks takes place, the lower beds of the limestone being usually more or less argillaceous and even slaty, while the upper layers of the lower rock are sometimes highly calcareous, including in certain districts regular and well defined deposits of limestone.

The limestone formation now before us occurs in many belts in the south-western half of the Appalachian region of the State. East of the Susquehanna and its West Branch, it shews itself less frequently, the only tracts in this quarter being: first, a thin and obscure stratum, lying usually about one mile north of the Kittatinny or Blue mountain, and stretching from the Swatara creek to the Water Gap of the Delaware river; secondly, a short but broader tract composing the limestone valley of Georgetown on the eastern bank of the Susquehanna river, in Northumberland county; thirdly, a band which emerges from beneath the overlying strata about two miles west of Berwick, and there separates into two belts, which encircle Montour's ridge. The most southern of these, ranges with a gentle south dip to Bloomsburg, crosses Fishing creek near its mouth, and afterwards the Susquehanna at Danville. It next recrosses the river about four miles further west and thence runs towards the West Branch, which it crosses about four miles north-west of Northumberland. The northern zone commencing at the same point west of Berwick, ranges with a moderately gentle northern dip (following usually the course of a valley) along the northern base of Montour's ridge. It passes a few hundred feet to the south of Mooresburg and thence reaches the low grounds above the mouth of Chilisquaque creek, where like the former belt it crosses the West Branch of the Susquehanna.

Besides these several zones of the limestone, all of which have been under careful examination, there are others which also lie east of the West Branch, but which are further to the north, and have not been yet explored.

That each of the belts mentioned consists of one continuous stratum, is placed beyond a doubt by the circumstance, that though often concealed for a mile or more in length by the loose materials of the adjacent ridges, or by a deep alluvial covering near the streams, we seldom fail to trace the rock either by the fragments on the surface or by the solid strata themselves, wherever any transverse valley or ravine crosses the ridges at the base of which the limestone usually ranges. It is equally obvious that all these several ranges are but different outcrops of one widely extended formation, for in every case the limestone occupies precisely the same position in the general series of our strata, always resting upon the shales of Formation No. V.

An interesting and important general fact concerning this limestone stratum, is its increase of thickness at each successive reappearance, as we recede from the Blue mountain going towards the north-west. In the south-eastern belt, or that which follows the north-western base of the mountain, its thickness probably no where exceeds one hundred feet, and it would be nearer the truth to state its average dimensions at from *forty to fifty feet.* A careful search on the Susquehanna river and for many miles east of it in the range of country where if it exist at all, it ought to shew itself, has served to establish the fact of the total absence of this stratum for many miles along the foot of the Blue mountain, but guided by a knowledge of the position which it should occupy in relation to the other strata, I succeeded in finding it immediately north of the Gap of the Swatara creek. Though at this point it is not more than from twenty to thirty feet thick, and quite impure, from the amount of argillaceous matter in it; yet it is convertible into lime, and will prove a real benefit to the agriculture of the immediate neighborhood. An accurate clue to the position of the stratum being once established, its developement at various other points east of the Swatara soon followed, and I am now enabled to announce my belief that this limestone may be detected from the Swatara creek to the Delaware river, at almost every cross ravine or valley which intersects the base of the sandstone ridge next north of the Blue mountain. Near the Swatara this hill is called Swope's ridge, but it takes several names in different parts of its course, which is not much interrupted from the Susquehanna to the Delaware. The place of the limestone is usually near its southern base, though at a few points between the Little Schuylkill and the Lehigh, and also between the Wind Gap and the Delaware river, it occasionally rises to the summit and even overlaps it on both sides.

The formation evidently augments in thickness as we advance eastward towards the Lehigh, though between the Wind Gap and the Water Gap of the Delaware, in its prolongation by the northern side of Cherry valley, it gives signs of again diminishing and becoming impure and slaty. It is very thin and decidedly argillaceous where it occurs a few miles south of Stroudsburg. North-east of the Delaware Water Gap we have not succeeded in tracing it far, and there would seem to be a strong probability that it does not continue more than a very few miles in that direction, as the belt of country which ought to contain it in Sussex county, New Jersey, has been more than once explored.

Another limestone very analogous in its general aspect and in some of its fossils, but much thicker, and occupying a somewhat superior position in the series, commences not far from the Water Gap and of course near the termination of the former, and ranges extensively towards the north-east, holding the same relative position to the Kittatinny mountain. It is important that we should not confound these two calcareous formations.

It would be entering too far into details to mention in the present report the numerous points where the limestone stratum constituting Formation No. VI, has already been detected along the several ranges whose general course I have described. I have deemed it of use, thus to draw attention to the regularity with which it ranges, that those who are disposed to convert it into a fertilizer of their soils, or employ it as a flux in their furnaces, may, by a knowledge of its exact relative position to the other strata, readily obtain it.

It may be of service to state, that as a general rule, the lower beds of this limestone, where it adjoins the subjacent red and variegated shales, afford a lime in which the chief impurities are clay and oxide of iron, while the upper strata being contiguous to an overlying sandstone, yield a material more or less sandy. Thus it is often practicable with very little difficulty, to select such portions of the formation for quarrying, that the quality of the lime shall be adapted to the peculiar nature of the soil which it is intended to fertilize, or of the ore which it is designed to flux. The two belts of this limestone ranging along the sides of Montour's ridge and thence nearly to Berwick, are the only ones to be found for many miles north or south, and lying as they do, near to the North Branch canal, they furnish a source of lime of great importance to a long and wide tract of country, embracing the Wyoming valley.

Iron ore would appear to prevail very generally in the soil covering this limestone. It possesses all the characters of the ore which I have mentioned in my former report as belonging to the same formation in its various belts throughout the counties lying south-west of the Susquehanna in the Appalachian district. Thus it occurs in some abundance at Bittenbender's, five and a half miles south-west of Stroudsburg, and exists also, though not yet found in much quantity, near the western end of Montour's ridge.

This ore is almost invariably of a light brown, approaching to a chesnut colour, and has a uniform, compact and rather argillaceous texture. Having examined it at a great number of points on both sides of the Susquehanna river, it is yet doubtful whether it occurs in sufficient amount at any one place along the limestone belts described in this report, to become extensively useful.

About three or four miles north-east of Northumberland a deposit of *bog iron ore* occurs, connected apparently with this formation. Though the excavation has not yet proceeded far enough to determine its actual thickness, the superficial extent has been proved to be considerable, and should it on trial be found to make good iron, it may become very useful for mixing with the rich calcareous ore of Montour's ridge.

Though this formation, and as I shall presently shew, the sandstone which overlies it, terminate towards the north-east near the Water Gap of the Delaware, they both occur in numerous interesting ranges extending in the opposite direction as far as the interior of Virginia, and probably beyond.

From measurements made on Fishing creek across that belt of the limestone which ranges along the southern side of Montour's ridge, its thickness at that place is 900 feet very nearly.

FORMATION No. VII.

SANDSTONE OF THE FIRST RIDGE NORTH OF THE KITTATINNY MOUNTAIN.

Overlying the limestone just described, the rock which comes next in order in the series, is a white and yellowish white sandstone, which, in its ordinary aspect, especially in the lower beds, is a coarse and rather loosely cemented aggregate of nearly pure siliceous sand. In the layers next to the limestone, when that formation is present, the composition of the rock is slightly calcareous, as shewn by the mode in which the weather acts upon it.

Its most characteristic feature is an abundance of definitely formed cavities, which are the hollow moulds of various kinds of fossil shells and other organic remains which have at one time existed in this sandstone, but which the porous structure of the rock has enabled the water long since to dissolve and carry away. These easily recognized pits occur only in certain beds, and are not equally plenty in every portion of its extensive range. They are not as numerous in proportion to the thickness of the stratum, in the belt which lies immediately north of the Blue mountain, as in some of the other tracts further towards the north-west.

Contrary to the rule observed by the underlying limestone in passing through its gradations of thickness, this sandstone appears to be most massive in the belt nearest to the Kittatinny mountain, or more properly in the south-western portion of it, near the Susquehanna river. In the ridge which crosses the river about half a mile north of the Blue mountain, its strata are well exposed for examination and measurement, being in a nearly vertical attitude. Their thickness at this point is about 700 feet. In this quarter, the rock is more compact, and of a greyer colour, and a closer and finer texture than in most of the other districts, and it contains fewer fossil impressions. These, however, are not entirely absent, but exist, though sparsely, in certain layers, which as usual are among the coarsest in the formation. Tracing it eastward, we find it in Swope's hill, near the Swatara, greatly reduced in thickness, and possessing its ordinary texture and aspect. In some of the beds south of Pine Grove, the rock encloses a multitude of the hollow pits, attributable to various species of marine remains, some of the distinctive features in whose structure, are easily discernible. In its course towards the north-east, the out crop of this rock, except when cut down to the common surface by some denuding action, occupies invariably, a steep and ragged ridge, distant from half a mile, to more than a mile, from the Blue mountain. Extending towards the Delaware with a slowly diminishing thickness, it seems to vanish entirely before reaching the Walpack bend of the Delaware river, about sixteen miles above the Water Gap.

In several parts of this range, especially those adjacent to the Delaware, the lower portion of the formation near its contact with the underlying limestone, contains thin layers of *chert* or flint, such as form a constant feature in the belts of the stratum more remote from the Blue mountain, particularly in the counties south west of the Susquehanna. On the Lehigh, and also near the Delaware, a similar, rather thick bed of chert, rests upon the upper side of the stratum, lying along the north-western base of the sandstone ridge.

The materials of this formation, though susceptible of few useful applications, are well adapted to various architectural purposes. Some of the strata not only furnish an excellent common building stone, but being massive, and readily quarried and dressed, they are much used in the construction of the canal locks on the Juniata.

One variety of the rock, recognized by its porous structure, its coarse and uniform texture, and its pure siliceous composition, seems to be well suited for the hearths and in-walls of furnaces; its only imperfection as a hearth-stone, being the difficulty sometimes encountered of getting it in masses of sufficient size.

This sandstone formation, with its accompanying chert, borders the little valley of Georgetown, on the Susquehanna, on the north and south sides, in two converging belts. Though the stratum is here much thinner than in the range next to the Blue mountain, its dimensions are nevertheless considerable.

It is evident that only obscure traces of the formation occur on the northern and southern sides of Montour's ridge, where, if it possessed any conspicuous thickness, it could not fail to be distinctly recognized in some of the many transverse valleys which expose the strata in that anticlinal axis.

Occasionally; loose fragments of it are seen on the surface, near the range of each of the limestone belts of that neighborhood, and from the very sandy character of the soil along the same line, it is not improbable that a thin, and perhaps continuous zone of this sandstone, may rest in contact with the limestone, having been, from its easily crumbled nature, worn down and covered by loose materials to a greater depth than the other harder formations adjoining.

FORMATION No. VIII.

THE OLIVE COLOURED SLATE OF THE VALLEY BETWEEN THE KITTATINNY AND SECOND MOUNTAINS.

The formation which next presents itself in the ascending order is remarkable for being one of the most widely diffused of all the strata of the Appalachian region, and for the constancy with which it preserves over a very wide area, the marked peculiarities of its structure, colour, and composition. In the counties especially referred to in the present report, it consists chiefly of an extensive series of alternating strata of dark grey, greenish and olive coloured slates, and soft grey argillaceous sandstones. The lowest beds consist of a nearly black, easily divisible and somewhat calcareous slate, while the grey sandstones abound most in the higher parts of the mass. These upper layers composed of slates and sandstones in frequent alternation and in nearly equal quantity, gradually become as we ascend, first brown and then red, until we cease to distinguish them from the lower beds of the great red slate and sandstone formation immediately above.

All the several varieties of this rock, its slates, sandstones and especially its limestones, where these latter exist, are conspicuous for the profusion of the interesting fossils contained in some of their beds. The whole stratum is more or less calcareous, and this circumstance, together with the quiet condition which appears to have prevailed in the waters during the deposition of this very thick formation, may explain the abundance and variety of the organic remains.

This formation occurs in several very long belts in the region east of the main stream of the Susquehanna and of its West Branch. The most southern range tracing it from this river eastward, occupies the central part of the valley between the Blue mountain and the second or Mahoning mountain as far as the latter ridge extends, which is to the Lehigh river. Thence in a somewhat broader zone it pursues the same general course between the Blue mountain and the base of the Pokono until it meets the Delaware river immediately above the Water Gap. From this point it follows the valley of the same river, the widest part of the belt being on the north-western or Pennsylvania side, and leaves our State at Carpenter's Point to sweep in a long curving tract entirely across New York.

Between the Schuylkill river, and the Easton and Wilkesbarre turnpike, the belt is generally double, a long and narrow zone of the overlying red sandstone beds of Formation No. IX. lying in a trough in the middle of the Mahoning and Fire Line hills, between the northern and southern ranges of the formation.

This Olive Slate formation occurs, again in a tract, of the form of a long and narrow triangle in the northern part of Dauphin county, extending eastward from the Susquehanna at Halifax and contracting to a point towards the sources of Armstrong's creek.

It occupies a considerably larger tract of a somewhat similar triangular shape in the southern part of Northumberland county, enclosing the limestone valley of Georgetown on its western side next the river, and narrowing to a point near Zimmermanstown, in Schuylkill county. Opposite Selinsgrove another long and wide range of Formation No. VIII, encloses another area of the same limestone formation and stretches eastward through the Shamokin and Roaring creek valleys, to within about two miles of the ridges which unite the Cattawissa and Little mountains. It also extends in a still larger and broader double zone along the valley of the North Branch of the Susquehanna, from its mouth to the mouth of the Wapwallopen creek, the valley of which stream it thence ascends nearly to its source. —The western half of this tract is double, being divided by the long and narrow range of the formations of Montour's ridge, and their continuation eastward to near Berwick. From Montour's ridge, northward to within about two miles of the foot of the Allegheny mountain, a large portion of the country on the eastern side of the West Branch is composed of this formation, where its strata are finely displayed in the passage of the river through the Muncy hills. The great width which this range of the formation exhibits in Columbia and Lycoming counties, is much reduced, after it enters Luzerne, where following its usual northeastward course it passes between the Shickshinny and the Allegheny mountains, and tapers to a point somewhere east of Harvey's Lake. Another belt of the same rock skirts in many places, the northern border of our State, ranging in a nearly east and west direction, and rarely spreading itself more than a few miles to the south of the Pennsylvania and New York line. It is displayed at the Big Bend of the Susquehanna where it presents all its distinctive features.

The more obviously useful materials derivable from this Olive Slate formation, are as far as regards Pennsylvania, rather few, and these occur in relatively inconsiderable quantities. In regard to the *ores of iron* both it and the several overlying formations as high in the series as the conglomerate beneath the coal measures are singularly deficient. In Perry county, near Bloomfield, it does indeed contain a very excellent variety of iron ore, and in considerable abundance. But the circumstances which seem to have given origin to it at that place are somewhat peculiar, and hence this mineral is not to be regarded as generally occurring in the formation. Should the rock elsewhere occur in similar topographical relations to the other underlying strata, similar deposits of the ore will probably be found, which a more detailed examination of some parts of the stratum not yet explored may possibly bring to light.

Some of the layers of this rock from a resemblance in their colour to the shales of our coal measures, and from their containing at times sufficient carbonaceous matter to cause their partial ignition when highly heated, are very frequently mistaken by those who are ignorant of the true relations of our coal bearing rocks, for unequivocal indications of anthracite or bituminous coal. These delusive appearances occur at the Big Bend of the Susquehanna.

No formation of our whole series has seduced so great a number of persons, into abortive explorations after coal. It may be useful, therefore, to embrace this occasion to state, that I feel satisfied that the formation, wide as is its range, contains no coal, in any part of the United States, and that in Pennsylvania, it occurs by calculation, at a depth, rarely less than 8000 feet below the lowest coal seams of any of our coal regions.

This formation is commonly more or less calcareous, and embraces occasionally very thin, though impure layers of Limestone, in general only a few inches, or at most, two or three feet in thickness.

One of these layers ranges rather interruptedly from Pine Grove across the Schuylkill, and past Orwigsburg to near Lehighton, on the Lehigh. Another is seen a little south of the ridge bounding the Limestone (Formation No. VI.) of the Georgetown valley, on the southern side. A third small bed may be recognized among the strata exposed on the Shamokin creek, in its passage along the base of the Shamokin hills. With particular care in the calcination, the Limestone of some of these bands may be converted into a rather inferior kind of lime; though with a few exceptions, the poor quality and insignificant quantity of this stratum, will not authorize much expense in the attempt.

On the northern branch of the Appalachian creek, there is a hill of considerable elevation, rising on the north side of the stream, and over which the State line crosses. Nearly on the summit of this hill, though rather on the northern declivity, within less than half a mile of the State line, and about a mile and a half from the line of Bradford county, a considerable deposit of limestone occurs, which promises to be very useful to the surrounding neighborhood, as lime is an article much wanted in this region.

It appears to be a mere enlargement of a calcareous band, in No. VIII. covering an area of fifty or sixty rods in length, and six or eight in breadth, having cross joints and being easily quarried. It does not seem to be a very pure carbonate of lime; but is rather siliceous and somewhat ferruginous, and when burned will yield an indifferent lime, of a grey or reddish colour, though for building and agricultural purposes, it will probably be found highly useful in a region where hitherto the lime used, has been obtained from a great distance.

Some parts of this formation, particularly the greenish or olive coloured slates, would seem to contain a small quantity of the oxide of manganese; and accordingly, where the mountain streams traverse a sufficient surface of these strata, the oxide of manganese, by the disintegration of the rocks, is not unfrequently found in the form of a black heavy powder, in the beds of the rivulets, where it may sometimes be collected in adequate quantity to render it an article of commerce. The oxide of manganese, from this source, can rarely be wholly separated from the earthy impurities with which it is mingled, and hence, as well as from the very low price of the drug, procured so very cheaply as it is from the mines of Europe, it can rarely justify much expense in collecting it. This oxide of manganese is tolerably abundant near Dr. Ball's, about four miles north-east of Milford in Pike county, and at other places in the same region.

Near the base of the olive slate formation, there exists a very interesting and important limestone stratum, stretching over a great range of country, from near the Delaware Water Gap, where it first obscurely shews itself, to the Helderberg mountains, south-west of Albany, and thence by a wide sweep to the westward, across New York to the Falls of Niagara.

From near the Water Gap this calcareous rock keeps the Pennsylvania side of the river to the Walpack bend on the Delaware, where it crosses into New Jersey, which it traverses in the same north-eastern direction as far as Carpenter's Point. Throughout all this part of the belt, the limestone is accessible from either side of the river, and it is to be lamented that so little of the rock is converted into lime by our farmers of Pike and Monroe counties.

This limestone deposit is a source of incalculable benefit to the highly fertile counties in the middle and western parts of New York, through which State it passes in a broad zone, generally bordering the Erie Canal upon the south. Its lower strata furnish the valuable beds of *Plaster of Paris* (or Gypsum,) found at Manlius, Syracuse, Tonewanta creek, and various other places; and from nearly the same part of the deposit is derived an inexhaustible supply of *hydraulic cement.*

Besides these useful materials, the pure limestone beds in the upper portions of the stratum, produce some of the best building stones of that State.

These facts are here briefly announced, because they suggest to us some highly important inquiries in reference to that portion of the formation which enters Pennsylvania, or closely approaches it in passing down the New Jersey side of the Delaware. Have we within our State, or at an accessible distance, the beds of gypsum and cement which characterize this formation on the Erie Canal? As well as I have yet been able to ascertain, the gypsum deposits would appear not to occur as adjacent even as the Helderberg hills, in New-York.

The great limestone stratum of the middle and western counties of New York, being a member of our olive slate rocks or Formation No. VIII. of the Pennsylvania series, its lower beds partake of the composition of this slate stratum; some of the beds of which, of greater or less thickness, generally lie beneath it. But the olive slate is in many parts of the formation conspicuous for the large amount of the sulphuret of iron in its composition, (having from this character been termed by Professor EATON, who first described it in New-York,) "*Pyritiferous Slate.*"

In accordance with some views of the origin of gypsum, occurring under analagous circumstances in Virginia, first brought to my attention by my brother, Professor W. B. ROGERS, we may conceive a chemical re-action to take place naturally, between the oxygen of the air contained in the water which penetrates the strata, and the sulphuret of iron of the slate, and the carbonate of lime of the alternating calcareous beds. By well known chemical affinities, sulphuric acid will be developed and a union will ensue between this and the lime, forming the sulphuret of lime, or gypsum.

The rain water filtering through the strata and carrying down in solution the carbonate of lime, to distribute it ultimately through the layers of the shale, must greatly promote the process; but it is by no means improbable that the two ingredients furnishing the gypsum have been to a considerable extent deposited together originally, so that the production of this substance may have commenced at a very early epoch.

From the Helderberg hills to the Delaware Water Gap, there would seem to be an absence of this close association of the carbonate of lime and the sulphuret of iron in the formation, for there is no series of alternating beds of the shale and the calcareous rock, such as we witness near Syracuse and other places in New-York. This I have ascertained by examining the base of the limestone formation on the Rondout creek, near the Hudson, and again in many places in New Jersey, pursuing it from Carpenter's Point, by Milford, to the Walpack Bend of the Delaware, and thence into Pennsylvania, and along the same line of strata to the Delaware Water Gap.

Nevertheless I would not wholly discourage a search for gypseous deposits in the belt of this formation which ranges along the south-eastern side of Monroe county, for though I have but faint hopes of its existence, its discovery would be fraught with such extensive and lasting benefits to all that section of our State, that the mere possibility of finding it is enough to sanction a careful inspection of the strata, along this belt of country. It is my intention to devote some further examination to this matter, during the progress of the survey.

We possess a belt of hydraulic cement near the base of Formation No. VIII. and in a position nearly corresponding to that of the cement beds of New York, though the material seems to wear a somewhat different aspect and composition. It usually lies immediately on the northwestern side of the sandstone ridge, next north of the Blue mountain, and dips generally to the northwest. It occurs near the Lehigh Water Gap at several places in the position mentioned, and also at various points along the same range towards the Walpack bend of the Delaware. Its colour is generally a dark dull blue, or rather a blueish grey, and its texture nearly that of a compact earthy limestone.

The water of the Olive Slate Formation, is apt to be hard and to contain some saline matters, especially sulphates of iron and alumina or in some instances carbonate of lime.

The soil is usually thin and not productive, but carefully tilled with a liberal and judicious application of lime, it is often found amply to repay the toil and enterprise of the farmer.

This formation will be recognised by the description given above of it, and by its relative position to the other strata of the Appalachian series. It forms the principal stratum in many of the valleys in the counties southwest of the Juniata. It may be traced along the entire line of the valley, which lies at the southern and south-eastern foot of the Table Land of the Allegheny mountain, from Luzerne county, to the Potomac river, and its range through Virginia, is even more extensive than through our own State.

The average thickness of the Olive Slate Formation east of the Susquehanna, is probably not less than 4,000 feet, and on the Lehigh, below Mauch Chunk, it materially exceeds this amount.

On the Susquehanna between the Blue mountain, and the Second mountain, it is very nearly 3,500 feet, and on the North Branch of the same river, it measures near Cattawissa, 4,471 feet, shewing a progressive diminution in the magnitude of the formation as we advance towards the west.

FORMATION No. IX.

RED SANDSTONES AND SHALES OF THE SOUTH-EASTERN SLOPE AND BASE OF THE ALLEGHENY MOUNTAIN.

Overlying the olive colored and grey slates and sandstones, described in the preceding section, we observe in many extensive districts of the State, another still thicker series of sandstones and argillaceous shales, very analogous to the previous group in texture and composition, but differing in the one obvious feature of colour, which in the greater part of the formation before us, is a brownish red.

It has been already mentioned that the bottom layers of this group, alternate with the upper ones of the underlying olive coloured series. Indeed many of the intermediate beds shew a dusky brown tint, a mingling manifestly of the colours, distinctive of the two respective formations. In the lower half of the mass, red shales and very argillaceous red sandstones predominate, while the higher parts contain a large proportion of beds of siliceous sandstone, generally reddish or brown, but sometimes grey, greenish grey, and buff coloured. In this half of the formation, the rock which occurs no where in very massive beds, has generally a tendency to divide into thin flagstone strata, of one, two or three inches in thinkness. This is in part, owing to the greater or less quantity of mica in it. The mode in which these sandstones were originally deposited in layers, slightly oblique to the stratification gives it a cleavage, which is not exactly parallel with the true plane of the dip, which is therefore rendered sometimes a little difficult to be traced with scrupulous precision.

As a formation, this series of reddish slates is even more generally deficient in useful minerals, than the olive coloured group immediately below it. It seems to contain some compact red iron ore, especially at certain points in the range which extends along the Allegheny mountain, but no sufficiently rich deposit has yet been developed to justify a more particular mention of it in the present report. A few very promising places have been partially examined, and a clue procured which will assist in tracing the ore hereafter, should its quantity sanction a minute exploration It occurs on Pine creek, Larry's creek and Lycoming creek. Some of the red shales, as at the Blue hill near Northumberland, are occasionally coated with a very thin pellicle of greenish matter, supposed to be carbonate of copper, but no ores of either that metal or of lead have yet been found, nor do they probably exist in more than very insignificant quantities in this formation, within our State.

Some of the materials of this formation, especially of the higher strata, are well adapted for architectural uses, being durable and easily shaped, though not ornamental as respects their colour. An inexhaustible supply of very superior flagstones for the pavements of towns, might be sent from many quarters of this widely distributed formation.

In regard to the fossils in this rock, a very manifest deficiency is observable, when compared with those in the stratum beneath it.

The change from the more tranquil sediments of the olive coloured rocks below, seems to have been accompanied by the extermination of the greater portion of the inhabitants of the ancient deep in those quarters at least where these red materials were deposited.

Nor do we find any animal organic remains, except in very rare instances in either of the overlying rocks, until we reach the uppermost formation of the entire group of strata, or that including the coal, and then only in the beds composing the bituminous coal measures.

Throughout our American formations generally, the red slates and sandstones, are remarkable for a deficiency of fossil shells, and other marine animal remains.

Near the junction of this formation, with the coarse whitish, and light grey sandstone stratum next above it, the reddish coloured beds are often replaced by yellowish and buff coloured strata, increasing in number as we ascend, and in the south-eastern belts of the formation, the transition from the one rock to the other is marked by beds of coarse red sandstone, containing numerous large white pebbles of quartz, composing a massive conglomerate. This variety is a durable rock, and fit for many purposes of architecture and construction.

It would not be compatible with my present limits to more than hint at the general range of this widely extended formation. Composing as it does in the north-eastern extremity of the State, some high mountain tracts having the same geographical range with some of the Anthracite coal regions, it was formerly, and is even yet, by many, supposed to be connected with a coal formation.

As no coal can possibly belong to this stratum, from its position in the series, it is the more important to specify in general terms, the mountain belts and districts of country which consist of it.

By far the widest track of this formation is in the counties northwest of our Anthracite coal basins. Thus it composes more than two-thirds of Pike and Munroe, occupying the whole of the broad table land of the Pokono mountain, spreading from its south-eastern base north-westward, as far as the Wyoming and Moosick mountains, and northward, so as to embrace the whole of Wayne, with the exception of the northern end of the Lackawanna coal basin, and a narrow belt of the Olive Slate formation in the northern side of the county. It forms also nearly the entire surface of the county of Susquehanna, excepting a similar zone on the side next the New-York line, and excepting also some high insulated mountain tracts in the prolongation of the Allegheny, as the knobs of the Mahoopeny and Tunkhannock mountains, which are capped by the next overlying formation. It ranges in almost horizontal strata, along the whole length of the Allegheny mountain, from the North Branch of the Susquehanna to the Potomac, in a belt from one to three miles broad, following its southern and southeastern base, and constituting the entire flank of that mountain nearly to its summit.

Another belt leaves the wide broad area of the formation in Pike and Monroe, and passing south-westward along the base of the Pokono mountain, crosses the Lehigh, and thence, in a narrow line, follows the valley, at the southern base of the Mahoning, or Second mountain, to the western side of the Susquehanna. In Perry county this belt expands somewhat in breadth, doubles round the termination of the Cove mountain, and recrosses the Susquehanna at Duncan's Island. It then ascends the valley of Powell's creek, ranging along the northern foot of Peters's mountain, sweeps northward to the southern base of Berry's mountain, along which it ranges in a zone about two miles wide, from near the head of Armstrong's creek, westward across the Susquehanna. It then crosses the Juniata, and pursues the same course, ascending the valley of Buffalo creek for several miles. At the Juniata it curves rapidly back, around the termination of the Buffalo mountain, and runs north-eastwardly, crossing the Susquehanna at Liverpool, and following the northern base of the Mahantango mountain by the valley of the creek of the same name to the junction of that ridge with the Line mountain, a few miles east of Zimmermanstown. Its next course is due westward, down the valley of Schwaben creek, along the southern side of the Line mountain. Passing along the Susquehanna, it penetrates some miles into Union county, where it sweeps back again to assume once more a north-eastern course, encircling the end of the Mahonoy mountain at the river, and ranging along its southern flank and base to the head of Roaring Creek valley. From thence its direction is westward to Northumberland,—the Blue hill, and a tract for some miles westward, being the end of this particular portion of the formation. But doubling round the end of the Cattawissa mountain the belt resumes its north-eastern course along the northern slope and base of the Nescopeck mountain, which it follows nearly to the head waters of the Big Wapwallopen creek, where, folding back once more, to take a westward range, it pursues the southern side of the Wyoming mountain, passing some miles beyond its western termination to the neighborhood of Jersey Town, in Columbia county.—Before reaching so far to the west as this, the belt makes an elbow once more, and folds round the end of the Knob mountain, the prolongation of the united ridges of the Wyoming and the Shickshinny mountains. Thence it ranges in a moderately wide zone, along the north-western side of the Shickshinny mountain, and the ridge continuous with it, and meets near the North Branch of the Susquehanna, the termination of the long belt which ranges along the south-eastern base and flank of the Allegheny mountain, from the southern side of the State to this point. From this place of junction near the North Branch of the Susquehanna, of these two last mentioned and extensive belts of the formation, it spreads in almost horizontal strata over a wide extent of region thro' Wayne, Susquehanna and the north-eastern portion of Bradford counties.

Passing north-westward out of our own State, this Ninth Formation of our series follows the prolongation of the Pokono, thro' Pike county, in a broad and high chain, augmenting in elevation until it reaches its termination in the grand peaks of the Catskill mountain, near the Hudson. The strata from the base of the Catskill mountain to within a few hundred feet of its loftiest summits, through a thickness, probably of 3000 feet, belong exclusively to this formation, while those which crown the highest parts of the mountain are conglomerates referable to the *tenth* member of the series of our Pennsylvanian rocks. This *ninth* stratum is a conspicuous rock, throughout the whole northern frontier of our State, for sweeping round the base of the mountains, near Towanda, at the eastern extremity of the great bituminous coal region, it ranges westward in a broad belt, parallel to the coal measures on their northern margin, through the northern portion of Bradford, Tioga, Potter, M'Kean, Warren and Crawford counties, and passes thence into Ohio.

Measured at different places near the several anthracite coal basins, the dimensions of this stratum has been ascertained with considerable exactness, and many facts regarding its variations in this respect determined.

The average thickness of the formation must exceed 5000 feet, the greatest magnitude appearing in the belt along the southern base of the second mountain in Northampton, Schuylkill and Dauphin counties, while a gradual abatement is discernable as we pass towards the north-west and approach the Allegheny mountain.

FORMATION NO X.

SANDSTONES AND CONGLOMERATES OF THE SECOND MOUNTAIN AND OF THE SOUTH-EASTERN SUMMIT OF THE ALLEGHENY.

We ascend from Formation No. IX through a series of alternating strata, usually several hundred feet in thickness, comprising red shales and red argillaceous sandstone allied to that formation, and interposed grey sandstones and red and grey conglomerates connected with the heavy overlying deposits of Formation No. X, which formation I now proceed to describe.

The lower portion of the mass includes white and grey siliceous sandstones with interstratified beds of dark bluish and greenish slates, sometimes resembling the shales contigious to coal, by having occasionally sufficient carbonacious matter in their composition to ignite, when highly heated.

The middle and upper strata are alternations of coarse silicious conglomerates and grey, bluish grey, yellowish and white sandstones, including in some districts thin layers of olive colored and black slates.

The principal useful applications of this rock are to the purposes of architecture. Great caution however is requisite in the selection of the particular layers. A too indiscriminate introduction of its various sandstone beds, but especially of its lower strata which alternate with the upper ones of Formation No. IX, has already resulted in the construction of some of our public works, in the destruction of an immense amount of capital to Pennsylvania. From the fact that a portion of its strata resemble in some degree a part of our coal measures, and at the same time, overlie a red shale and sandstone deposit, having a considerable analogy to that beneath the Anthracite coal basins, a mistaken belief prevails in the minds of many of our citizens that this rock belongs to the genuine coal formation of the State. Explorations in search of coal, sometimes expensive ones too, are almost daily undertaken, incited by visionary hopes which have no better foundation than vague mineralogical analogies and unscientific attempts to identify our strata.

Upon the summits of the Allegheny mountain where the upper surface of this rock immediately adjoins the base of the conglomerate stratum upon which all our coal measures repose, (there being no red shale interposed,) the difficulty of recognizing the true character of this formation is considerably increased, and erroneous anticipations respecting the occurrence of coal in that part of its range are consequently frequent; but unless indeed it be in Virginia, where from the investigations of my brother, Professor W. B. Rogers, it would appear that some small and as yet unproductive beds of coal do really occur in this rock or its equivalent, I entertain no expectation that research will ever develope a profitable seam of either variety of that mineral in this formation.

For the present, a sufficiently correct idea of its range is presented in the following brief enumeration of the mountains and ridges of our State which consist of it.

Commencing our tracing on the southeast, it caps the Big Creek mountain, east of the Lehigh at Mauch Chunk and the Broad mountain a continuation of this, as far westward at least as the Little Schuylkill.

It forms the main summit and northern side of the second mountain from the Lehigh to Perry county, where it composes the Cove mountain. It forms Peters's mountain, Berry's mountain reaching to the Juniata, the Buffalo mountain and its extension the Mahantango mountain; also the Line mountain and the Mahonoy, with its prolongation, the Little mountain: thence it extends along the Cattawissa mountain and its continuation, the Nescopeck mountain, to where this flattens out and joins the Wyoming or Moosick mountain, the whole of which from Wayne county to its junction with the Schickshinny mountain, in Columbia county, consists of this formation. It composes likewise the Schickshinny and its continuation the Lackawanna mountain, encircling through this and the Wyoming mountain, the whole of the Wyoming coal basin. It sweeps north from the eastern part of the Broad mountain, keeping east of the Lehigh, until in the neighborhood of Bear creek, it crosses this river and forms the flattened table land at the eastern end of the Nescopeck. The southeastern side of the summit of the Allegheny mountain consists also of this rock throughout its entire course from Maryland to the North Branch of the Susquehanna, beyond which I believe the formation is prolonged in the highest summits of the Tunkhannock mountain

This rock occurs fully developed also in Bedford and Huntingdon counties, holding a corresponding position outside of the coal basin of the Broad Top mountain, which it completely encircles, ranging through Sidelinghill, Terrace mountain, part of Allegrippus mountain and Harbour mountain, following these ridges in their continuation southward.

The thickness of this formation has not yet been determined, except at a few places in the State. From the measurements that have been made, it would appear to vary from about 2,200 feet, which is nearly its greatest depth in the belts adjacent to the Anthracite coal basins, to a thickness of only a few hundred feet in other parts of the State.

FORMATION No. XI.

RED SHALE OF THE ANTHRACITE COAL REGIONS.

The next formation in the ascending order, is remarkable for retaining its characteristic features and composition with more uniformity than perhaps any other in our entire series.

It consists almost invariably of argillaceous red shales and soft argillaceous red sandstones. Toward the base of the stratum when the materials partake somewhat of the siliceous character of the underlying sandstones last described, it embraces some beds of hard, compact, red sandstone, with occasional alternating layers, of a similar composition, but of a grey colour. Toward the middle of the mass the sandstones are more argillaceous, and softer, but still include beds of the harder gray variety, while the red shale is somewhat less abundant. This mixed character prevails throughout the upper third of the deposit, until we approach the base of the conglomerate stratum above, near which we generally behold a moderately thick alternation of the remarkably dissimilar rocks of the two adjoining formations, the red shales and soft red sandstones being interstratified with coarse grey sandstones and excessively coarse and massive conglomerates.

If much circumspection be used, the middle and lower portions of the formation may be made to yield very excellent flagstones and building materials, being procurable in masses of very convenient shape and possessing every requisite in respect to compactness and durability.

Many of the beds of this red shale and sandstone series are more or less calcareous, and a few of them are almost enough so to be considered bands of true limestone. The layers of this character closely resemble each other in composition, consisting of a kind of conglomerate formed of small ovate pebbles or kernels of limestone, of a light blueish grey and sometimes a faint greenish or reddish tint, imbedded though rarely in contact with each other, in a paste of soft argillaceous red shale. Occasionally the rock contains such an abundance of these little limestone pebbles which in shape and size are not unlike the smaller sorts of beans, and the cement uniting them is so calcareous that it possesses almost the purity of an ordinary limestone. When of this description it differs but little from common light blue and greenish grey limestones, except in the mottled appearance arising from its pebbles. This least impure variety has in a few instances been calcined, and has been found to afford a lime which though not very pure or white, is yet tolerably well suited for making mortar, though better adapted to the purposes of a manure for the soil.

The external aspect of this calcareous rock is so peculiar that any attentive observer will readily recognise it, even from the foregoing brief description. Its weathered surface possesses a singularly decayed and worm-eaten appearance in consequence of the greater solubility of the calcareous pebbles over the red argillaceous earth surrounding them, causing the outside to be studded with irregular pits from the partial removal of the small lumps of limestone. The inspection therefore of the weather worn exterior will exhibit better than a newly fractured surface, the relative amount of the carbonate of lime, compared with the impurities, in the rock.

The upper part of the formation would generally appear to contain the purest bands of this calcareous rock, but in some places they abound more in the middle and lower portions. For every such conglomerate bed, pure enough to calcine into lime, many will occur much too impure to warrant the experiment.

The thickness of these bands ranges from six feet to a few inches. A layer, pure enough perhaps to afford an indifferent lime, exists on the south side of the second mountain, in the valley of

Tum'ling run, three miles east of Mount Carbon. Another lies in the valley of Locust creek, about two miles northwest of Tamaqua, and presents rather better indications. Other beds, probably however much too impure for practical application, occur in the southern part of the Gap of the Sharp mountain, south of Tamaqua. The same rock is found near Mauch Chunk, and near Beach Grove at the western extremity of the Wilkesbarre coal basin. I have met with it tolerably pure in the red shale tract embraced between the Broad mountain and the Mahonoy mountain, not far from the road leading from Pottsville to Sunbury; but one of the purest belts yet examined occurs immediately at the western end of the Mahonoy coal basin in the red shale rocks near the outer base of the Big mountain, immediately at its termination on the Little Mahonoy creek.

I deem the calcareous rock of this last mentioned spot, which may easily be found, to deserve a careful trial by the farmers in its vicinity.

These are a few of the places in which this stratum has been met with. Enough is known to indicate certainly, that each of the anthracite coal basins is encircled by one or more bands of this rock. Whether it exists of sufficient extent and purity to furnish a supply of lime for the agriculture of the red shale valleys contiguous to the coal fields, is a question which further researches in these regions alone can settle. But no pains should be spared to ascertain its real value, since the valleys where it exists, are far remote from the limestone districts of the State.

A very brief description, will for the present, suffice to designate the range of the red shale formation. Encircling in a continuous zone, all the anthracite coal basins of the State, it usually constitutes a chain of deep and narrow valleys enclosed between the ridges of Formation No. X. on the one side, and on the other, those containing Formation No. XII. composing the margin of the coal measures.

The maximum thickness of this formation, occurs apparently, in its southeastern belt or that which ranges along the south side of the southern anthracite coal basin. From accurately conducted measurements made at Pottsville, the depth of the stratum at that place is about 2,949 feet.

FORMATION NO. XII.

CONGLOMERATES AND SANDSTONES IMMEDIATELY BELOW THE COAL MEASURES OF THE ANTHRACITE, THE BROAD TOP AND THE ALLEGHENY COAL REGIONS.

The stratum which occupies the next place in the series, is a group of siliceous conglomerates and coarse siliceous sandstones immediately subjacent to all the coal measures of the State, both in the anthracite and bituminous coal regions. It reposes upon the red shale formation just described, not only around all the anthracite basins, but also around the bituminous coal measures of the Broad Top mountain; while it rests directly on the upper surface of the sandstones of the next lower formation (No. X) along the entire length of the Allegheny mountain, the south-eastern margin of the great western coal field; the red shale deposit not extending that far towards the north west.

Confining the present description to the formation as it underlies the several anthracite deposits of the State, its mineral character which is well marked and liable to but little variation, may be given in very few words. The whole rock which is usually several hundred feet thick, consists of massive strata of coarse quartzose conglomerates, alternating with white, grey and brown sandstones, of rather diversified texture and composition, including occasionally, a few thin beds of dark carbonaceous shale.

The most abundant and characteristic rock is the conglomerate. This occurs in very heavy beds, especially towards the bottom and the top of the formation. Its materials are chiefly pebbles of white quartz with a few interspersed ones derived from the three rocks at the bottom of our series—the sandstone, the limestone and the slate, of the Kittatinny valley. The limestone itself would seem not to have been sufficiently hard to resist the attrition which accompanied the strewing of this enormous bed of shingle over the bottom of the ancient ocean, but the chert or flint belonging to the formation was better able to withstand the abrading action, and its pebbles, therefore, not unfrequently enter into the composition of the rock.

In the conglomerate there is rarely much sand or other finely divided matter separating the pebbles from each other, which are most commonly in close contact, the rock being nothing else than an aggregate of rounded fragments of white quartz varying from the size of a pea to an inch in diameter.

We observe a regular and manifest diminution in the size of the component pebbles and in the thickness of the stratum, as we pass successively from the Sharp mountain on the southern side of the southern anthracite region, to the belts which surround the middle and northern basins. At the same time the materials assume a more uniform size, and the entire mass grows more homogeneous, becoming a nearly pure quartzose conglomerate. In some of the southern belts the pebbles vary in dimensions from the diameter of small shot to that of an orange, which indeed they occasionally surpass.

It is a fact of no small interest, as pointing out the violent action which immediately preceded the deposition of the first beds of coal, that the lowest seam in some places, is in almost direct contact with one of the very coarsest and most heterogeneous of the conglomerate beds of this formation.

It would appear indeed that the violent movements of the earth's surface which were the prelude to that new and remarkable order of things, which gave origin to the coal, and its accompanying strata, throughout the whole wide region embraced by our enormous coal fields, were not wholly terminated when the production of this material commenced. For at various places on the margin of the southern or Pottsville basin, a seam of coal occurs beneath a thick and very massive stratum of the coarsest sort of the conglomerate.

The uses to which this Twelfth Formation of the series is applicable are few. For massive structures such as the embankments and walls of rail roads, the rock of the conglomerate beds is exceedingly well adapted, and many of the finer grained sandstones are very fit for building stones. The compact and purely quartzose conglomerates, when not too coarse, may be converted into *millstones*, some having been occasionally made, it is said, of this rock, on the margin of the northern or Wilkesbarre basin. The material would appear to be not inferior for this purpose to that found at Esopus, on the Delaware and Hudson canal, which belongs to the conglomerates of Formation No. IV. So nearly alike in their constituents and aspect are the two rocks, that it is sometimes a matter of difficulty to distinguish between them.

The maximum thickness of this conglomerate formation seems to occur towards the eastern part of its most southern belt, or that which forms the Sharp mountain. Thus at Tamaqua it is probably not less than 1400 feet, whereas at Pottsville it is but 1031 feet, and at Pine Grove, considerably less.

Its thickness in the eastern portion of the Middle Anthracite Region has not yet been positively ascertained, but at Girardville it does not probably exceed 800 feet, while towards the western end, at the gap through the Big mountain, traversed by the Shamokin creek, it is about 700 feet. At Nanticoke, on the north side of the Wilkesbarre basin, it measures about 300 feet, and near Beech Grove, at the western end of the same valley, about 200 feet would seem to be the total thickness.

This diminution in the thickness of the formation as we proceed northward and westward, appears to be continued to the coal regions bounded by the Allegheny mountain, for at Towanda where it caps most of the higher mountains and supports a shallow mass of productive bituminous coal measures, the dimensions of this conglomerate do not probably exceed fifty feet.

It is not a little curious that this white siliceous conglomerate underlies not only all our vast bituminous coal region, to which it forms the south-eastern boundary along the Allegheny mountain, and the northern border along the high table land of our northern counties, but it occurs in a similar relative position along the edge of the same great coal basin in its continuation southward through Maryland and Virginia.

FORMATION NO. XIII.

THE ANTHRACITE COAL MEASURES.

I come next to describe in an equally brief manner, the Anthracite Coal Measures. These with the contemporaneous bituminous coal deposits of Broad Top mountain, compose the last produced or uppermost formation of the extensive system of strata occupying the Appalachian region of Pennsylvania. None of the other formations consists of so miscellaneous a group of materials: for these coal measures comprise, besides the beds of anthracite, an extensive series of shales, sandstones and conglomerates in frequently repeated alternations.

Among the coal seams at the base of the series, we often find a conglomerate of the very coarsest sort, identical in all particulars with the rock which characterizes the upper portion of the next underlying formation. This rock marks the gradation from the one set of deposits to the other and points to the curious fact that the processes which brought together the materials of the coal, commenced before the previous movements that caused the conglomerate, had wholly ceased. This very coarse aggregate has rarely more than one or two coal beds below it, and ascending a little in the series, we find that its place is supplied by thick beds of shale and masses of soft argillaceous sandstone, with occasional strata of coarse siliceous sandstones, some of whose layers have a sprinkling of pebbles which give them the aspect of conglomerates. These pebbles are smaller and more irregular than those composing the rock at the very base of the series. The coal and the slates immediately in contact with the coal, lie interstratified with these numerous coarse beds in an alternating group of great thickness.

Between the conglomerates, or even the coarse sandstones, and the beds of coal, argillaceous sandstones and blue shales are almost invariably interposed. The predominant rock of the upper part of the series is a compact blue sandstone, containing much argillaceous matter and oxide of iron which cause the atmospheric agents to decompose it superficially, and to impart a dingy brown colour, and a tendency to a conchoidal fracture and to a scaling off at the corners.

The shales which are next in importance to the argillaceous sandstones are commonly of a dark blue or blueish grey colour when freshly broken, but many of them by exposure to the atmosphere and to the vicissitudes of the seasons, assume a brownish ochreous hue and crumble rapidly to pieces. Occasionally these shales contain highly ferruginous bands, in some of which occur layers of tolerably rich argillaceous iron ore. In the Anthracite Coal Measures, as a general rule, this ore does not appear to exist in that abundance which it exhibits in many portions of the bituminous coal series north-west of the Allegheny mountain. Its quantity is, however, very considerable, and hopes are entertained that in the course of the enterprising mining operations and the geological explorations now on foot, valuable bands of the ore may be developed.

These blueish shales also contain, though not abundantly, very beautiful impressions of Ferns and stems of Calamites, and in the lower portions of the deposit, the stems and leaves of other curious vegetable fossils, as Lepidodendron, Sigillaria and Cactus.

In the immediate vicinity of the seams of coal, these shales become more or less carbonaceous, and acquire a darker colour and a more purely argillaceous texture. On such, the miners bestow the name of *coal slates*. These slates it is generally thought differ materially in appearance and composition accordingly as they lie above or beneath the coal seams. The overlying slate often contains innumerable extremely thin sheets of pure anthracite, minutely interlaminated with equally delicate layers of slate. This is technically termed *bone coal*, and is frequently mistaken by the inexperienced for pure anthracite, though it is easily recognised by its tendency to split into thin parallel layers, and by the number of the ferns and other delicate vegetable impressions usually found in it.

The underlying slate on the contrary, is of a much tougher consistency and of a more regular or well defined fracture, breaking into firm splintery masses instead of loosely aggregated scales.

These slates in contact with the coal beds, vary from one to twenty or even thirty feet in thickness, and not unfrequently occupy the entire space between two contiguous coal seams.

It would lead me far beyond the limits which I have assigned to the present brief sketch, to attempt even a general description of the several vast anthracite coal basins of the State. As was intimated in the early part of this report, many portions of these coal basins have yet to be explored in detail; want of time and of adequate assistance, having made it impossible to extend the minute investigations of the survey beyond certain limited districts.

Yet the mass of observations already collected would, if it were expedient to introduce them here, swell this report to more than four times its present magnitude. To be intelligible and really useful, they would require exemplification by geological maps, sections and numerous other drawings, the publication of which at the present time would be premature. I shall therefore postpone giving any systematic description, either general or particular, of these coal regions, and confine myself entirely to two or three insulated topics connected with peculiar features in their structure, which are of a nature to influence the success or failure of mining operations in certain tracts and districts.

When we advert to the usual shape and structure of the several great anthracite tracts of the State, we perceive that they are long and irregular basins which have assumed their form from the elevation on all sides of them, of the underlying rocks of the country in a series of nearly parallel belts, from which the strata dip in opposite directions. or technically. in a series of anticlinal axes. Thus the northern margin of the Pottsville basin and the southern one of the

Beaver Meadow and Mahonoy, or Shamokin basins, are the joint results of the elevation of the rocks below the coal in the intervening tract of the Broad mountain and its spurs; and in like manner, the particular sub-divisions of each basin have been made to assume a similar basin or trough-like form, (or that in which the strata dip from the margin inwards,) in virtue of the same force of upward protusion of the underlying formations, operating to tilt aside the uppermost or coal bearing deposits. This is well exemplified by the manner in which the Wiconisco basin has been severed from the Dauphin county extremity of the great basin of Pottsville, by the elevation of the subjacent rocks along the anticlinal axis, which passes through the country lying between Berry's and Peters' mountains. This axis gradually dying out to the eastward, permits these two mountains to coalesce, bringing together the two red shale valleys on their north and south, and finally, the two coal valleys themselves, near the head waters of the Swatara creek.

Connected with this violent upheaving action of the strata outside of the coal basins, enormous parallel *wrinklings* of the coal measures themselves, have taken place, causing great intricacy in the internal structure of many parts of these regions. This is augmented by the existence of great dislocations, the results of the same subterranean movements.

Directing our attention to the southern or Pottsville basin, for the illustration and application of these facts, let us examine some of the peculiar features which have there arisen from the agencies alluded to.—The most conspicuous point in the structure of this coal valley, and one intimately connected with nearly every other feature which belongs to it, is a remarkable dislocation, which I have proved to extend nearly from end to end of it, ranging a short distance from the northern foot of the Sharp mountain.

The strata giving way along this line through a length of perhaps fifty miles, those on its southern side have experienced an enormous downthrow. At the same time, the rocks of the Sharp mountain through an extent probably of thirty miles, have been heaved towards the north and tossed beyond the vertical position, so that these ponderous conglomerates lean in an inverted attitude on the entire thickness of the coal measures, which must lie buried in a more or less crushed condition for several thousand feet beneath its northern base.

At Pottsville, at Tamaqua and at Pine Grove, the exact position of this great fracture of the strata, has been detected, while ample and satisfactory evidence has at the same time been collected, which goes to shew that it ranges continuously through the intermediate tracts.

In consequence of the disruption of the coal measures near the northern base of the Sharp mountain and the *overtilting* of its strata, the coal seams which occupy its northern flank and which are several in number, have sustained a greater or less degree of crushing action, the result of a sliding of the beds in the plane of their stratification. Indeed it is not to be supposed that a group of massive strata many thousand feet in thickness, and composed of materials of almost every degree of tenacity known in rocks, could be upheaved from their originally horizontal position and tossed into a vertical posture, and even beyond it, without undergoing much displacement in a direction parallel with the surfaces of the beds. This action resembles the sliding upon each other of the leaves in a ream of paper, when we suddenly elevate one side and permit the parts of the mass to settle into new relative positions.

In a vast pile of stratified rocks, thus disturbed, the greatest amount of movement and consequently, of crushing force, would take place in the *weakest* layers, which in the case of coal measures, would be the beds of the coal itself. At the same time the strata would experience, especially if they were tilted into a nearly vertical attitude, an unequal lateral *bulging*, such as the sheets in the ream of paper will shew, when it is loosely placed on one end and the *lateral* pressure which preserved them in their places removed. Precisely these results are witnessed in the coal measures of the northern slope of the Sharp mountain, where the coal seams in many places exhibit the effects of a rubbing pressure, to an extraordinary degree.

For a great space in one of these, it is difficult to find a mass of coal exceeding a nut in size which does not give proof by its numerous fissures and highly polished surface, that its parts have been violently crushed. The whole mass has a tendency to crumble into small lenticular flakes which, in consequence of the friction which they have undergone, possess a lustre and a colour, somewhat resembling black lead, from which circumstance the bed has acquired the name of the Plumbago Seam. The lateral bulging of the strata is shewn by the variability in the thickness of the coal seams, the roof and floor of the bed approaching sometimes almost to touching, and at others receding to beyond the full space which should divide them. This alternate contraction and dilatation of the layer, occurs not only in the direction of its range, as may be seen in the horizontal galleries or drifts, but it exists in the opposite direction or that of the dip, and will render it as difficult to mine such seams with success by the method of *slopes* as by that of *levels*. To shew that these yieldings in the strata pervade the Sharp mountain throughout the greater part of its length, it is only necessary to mention that in every few hundred feet a change in the direction or bearing of the rocks is observable; the levels in the several mines which have been worked in the side of this mountain, between Pottsville and Port Carbon, exhibiting very frequently quite a surpentine course, the flexures however, being very gentle.

The variations in the course of the strata are usually embraced between a direction, north sixty degrees east, and one north eighty degrees east, so that any abrupt twist in the range of the rocks cannot occur, except, as in the case opposite Middleport, where the whole mountain as one mass, has been violently dislocated in a direction transverse to the strata.

I would not convey the idea from what has been said, that all the coal in the Sharp mountain is crushed and all its seams irregular.—Even were this the case, it would not follow necessarily, that some portions of them might not well repay the cost of mining, especially on the plan of drifts, entering at the ends of the strata in the gaps which divide the mountain.

It will sometimes happen that a slightly crushed or fragmentary condition in a coal seam, will require less excavation and permit the operations of the miner, if on a moderate scale, to be conducted with more economy. At the same time I would wish distinctly to make known my belief, that throughout this tract of the coal region, the causes alluded to above, must render the business of mining these nearly vertical and overtilted seams, precarious in a high degree.

Tunnels of several hundred feet in length, are occasionally carried through the hard coal measures of this lower portion of the series to gain access to the several thick beds of coal which lie in the side of the Sharp mountain, but they appear invariably, to have been undertaken under a persuasion which has not yet in a single case been realized, that a portion of the formation could be reached, unembarrassed by the features upon which I have just commented. My own conviction is, that those peculiarities in the structure of the Sharp mountain, constitute from their frequency a general rule, having perhaps, a few rare exceptions, which will hardly I conceive, unless indeed they are distinctly known to be exceptions, justify the expense of mining the coal, in case it must be done by tunneling.

An interesting fact, concerning the changes in the dip of the coal measures included between the Sharp mountain, at Pottsville, and the Broad mountain, goes far to confirm the views here adopted respecting a tossing over towards the north, of the strata on the south side of the dislocation. It refers to the particular form which generally prevails in the anticlinal elevations of the strata in this part of the basin: namely, the greater steepness of the dips on the northern, compared with those on the southern side of these axes. It is a common remark among the miners, that the north dipping seams are steeper than the south dipping ones, and of less continuance. The reason for this is very intelligible if we will advert to the manner in which the forces operated on the strata at the time when they were elevated.

The rising of the underlying formation in the lofty axis of the Broad mountain tilted the coal measures southward, at a considerable angle, over the entire width of the valley, as far as the great dislocation, but the action in that direction must have been met by the far more resistless force exerted by the Sharp mountain, pressed forward and leaning towards the north by its whole momentum and weight, so as to abut against the edges of the fracture. The tendency of this compression from the south, would be to wrinkle the strata, not in symmetrical anticlinal undulations, as we see them in the other basins, but to thrust the upper part of each fold or wrinkle, towards the north, and thus to steepen the northern inclinations more than the southern.

The waves on a surface of water will explain this. When the wind entirely lulls, the slope is equal on both sides of every wave, but when the wind presses strongly from any quarter, the top of each wave is urged forward from the wind, and the inclination on the far or leeward side is considerably the most abrupt. The geological section which has been measured across the basin at Pottsville, shews the existence of at least five important anticlinal elevations or changes of the dip, and it holds true of most of them, that the dips towards the north much exceed those towards the south. This applies even to the axis in Mine hill, which is an anticlinal elevation exposing the uppermost strata of the conglomerates below the coal, occurring at a distance of more than three miles from the dislocation, where the horizontal thrust towards the north must have been exerted.

Undulations in the dip of the coal measures, caused by numerous parallel anticlinal axes, are of frequent occurrence throughout all the anthracite basins. An exact knowledge therefore of their range and magnitude, and of the peculiarities which sometimes attend them, relating for example to the particular direction and character of the fractures and displacements, must prove of great importance to those who embark their capital in mining operations. These displacements though the apparent cause of the intricacy and confusion so common in the stratification of these coal regions, often maintain among themselves certain features in common, which when understood by the miner, may frequently lead in the prosecution of his work to practical views of incalculable advantage. Thus in the vicinity of Pottsville, the intelligent colliers have long been aware of the relative unproductiveness of the north dipping portions of the strata, though from not recognizing the cause, the fact has not been admitted as a general rule to the extent which it deserves, and injudicious enterprizes are therefore often undertaken in total disregard of it. At a later stage of the survey, it is believed some useful generalizations upon this important subject will have been arrived at; for the present I will allude very briefly to one or two, not however of a very local application.

A striking one is, that these anticlinal elevations of the strata rarely observe a direction quite parallel with that of the coal beds themselves. It would appear, that from the neighborhood of Pottsville, eastward, towards Mauch Chunk, the undulations in the dip most usually draw nearer to the Sharp mountain side of the basin as they extend eastward, thus crossing the true course of the coal measures a little obliquely. In the Shamokin basin, or the western half of the great central anthracite region, the reverse would seem to be the case, each conspicuous anticlinal axis shewing a tendency, in running eastward, to approach the northern barrier of that basin.

It is very important, from the great length of the levels and longitudinal galleries in many of the mines, some of them being nearly a mile in extent, to ascertain for each neighborhood, the quarter, whether east or west, towards which these undulations most commonly flatten out and disappear.

The vicinity of Pottsville was alluded to, to shew a peculiar feature of irregularity in the anticlinal axes, consisting in the greater steepness of the north dips compared with the south.

The coal fields at the eastern end of the great middle region, wil illustrate a very different structure, arising on the other hand from undulations of remarkable symmetry. The whole of this tract consists of a rather high rolling table land, between the summits of the Buck and Spring mountains, the outer barriers of the coal measures. It is traversed longitudinally, or in a nearly east and west direction, by three, and probably in some quarters, four nearly parallel gently swelling ridges, dividing the region into about four very moderately depressed valleys. These valleys are so many almost regularly formed little coal basins, in which the coal measures, as a general rule, have a very gentle dip towards the interior of each basin, or away from the bounding ridges. The ridges contain broad, rounded, obtuse, anticlinal axes, having the dips on both sides symmetrical, and expose across their summits, and on the upper portions of their acclivities, the conglomerate stratum which constitutes the formation beneath the coal. Much capital may therefore be thrown away in explorations for coal upon these ridges, or in the tracts through which their anticlinal axes are prolonged towards the east and west, if due attention be not paid to the structure of the coal field containing these lines of elevation. Some of the valleys on the other hand are richly supplied with coal, two or three of the seams which are those at the base of the formation, being of great thickness though the total depth of the coal measures, when compared with that in several of the other regions is materially less.

Besides these undulations of the dip, and other disturbances which interrupt the regular basin formed arrangement of the coal measures, in lines nearly longitudinal with the course of the strata, there are systems of *transverse dislocations* in many of the basins, less obvious to the explorer and miner, but exercising, if any thing; a still more serious interference with mining operations. To take the southern or Pottsville region for our illustrations, the numerous gaps and notches in the Sharp mountain, which is its barrier on the south, are nearly all of them connected with great fractures, extending *across* the range of the strata. These fractures indeed appear to have caused those gaps or breaches in the mountain by presenting a barrier, broken at various points, to the scooping floods which have swept alike, across our valleys and our loftiest ridges.

A frequent, though not an invariable consequence of these transverse breaks, is the derangement of the regular continuity of the strata on the opposite sides of the vertical plane in which the crush has taken place. The coal measures are thus abruptly broken off or greatly twisted and thrust out of their usual range, or to use a mining phrase, *horizontally heaved*, to the north or south of their proper position. This is most apt to occur at the streams, many of which flow through transverse valleys caused by the dislocations here spoken of. Seams of coal extensively mined and familiarly known on one side of a rivulet, often thus elude discovery when sought for on the opposite bank.

The successful recovery of these would however be greatly facilitated by a knowledge of the direction and magnitude of the horizontal heaves in each particular neighborhood. That knowledge can only be accumulated by the joint observations of the geologist and the miner, the one devoting himself to the study of all the phenomena which can cast light upon the inquiry, the other treasuring the hints which the first can furnish, and directing his attention to amass as great a variety as possible of local facts, collected from the mines in the course of his subterranean labors.

One of the most obvious of these transverse dislocations crosses the Sharp mountain and the coal measures at Lorberry creek northwest of Pine Grove. East of the gap by which that stream passes through the Sharp mountain, the strata in this southern barrier of the coal field range about south 72 degrees west, and dip in an *overtilted attitude* at an inclination of rather less than 70 degrees southward, while on the west side of the gap, the course of the rocks is south 57 degrees west, their posture being nearly vertical; the whole mountain and the coal measure north of it being at the same time moved or heaved towards the south as much as thirty yards.

It is probable that a fracture of the same kind passes through the gap of the West Branch of the Schuylkill, two miles west of Pottsville for the coal measures which eastward from this neighborhood are traceable with a moderate degree of regularity for several miles, appear no longer in their ordinary range when they are sought for on that stream. On the West Branch of the Norwegian creek, the strata indicate in like manner a displacement from their usual line of bearing, and the efforts to trace some valuable coal seams west of this water have hitherto ended in disappointment. Whether at these supposed cross dislocations of the strata, those on the western side of the line of crush have been heaved southward, as in the instance at Lorberry creek, or northward, is a question, the solution of which, would be fraught with important benefits to that portion of the coal region.

By far the most conspicuous north and south disruption of the coal measures and their southern conglomerate barrier, is displayed in an enormous dislocation of the entire chain of the Sharp mountain, about nine miles east of Pottsville, by which the whole mass of the mountain on the eastern side of the break has been moved northward through at least one fourth of a mile, throwing of course all the coal seams far out of their regular position.

A very analogous displacement in the same mountain ridge, and on a scale scarcely less considerable, occurs on the southern side of the basin at the Summit Mines of the Lehigh company, where the eastern prolongation of the Sharp mountain has been thrust northward of the western, through a distance of many hundred yards.—This has formed a broad, elevated, plateau, between the two disjoined summits of the mountain from which all the upper coal measures have been swept away and the strata denuded precisely to that fortunate depth, necessary to lay the vast deposit near the base of the series accessible on the surface of the hill. Thus an immense mass of coal has been speard out over a wide space in a nearly horizontal position, disturbed however by numerous sharp east and west wrinkles or parallel anticlinal axes. These undulations point distinctly to the transverse disruption of the mountain and the adjoining coal measures, as the origin of this remarkable table land.

In all the three instances here adduced, of great cross fractures affecting the Pottsville basin, the strata to the *eastward* of the dislocation are thrust forward toward the *north*, and such, though probably liable to many exceptions, would seem to be the general rule in this southern coal region. The numerous gaps and breaks in the line of the Blue mountain or Kittatinny, exhibit very generally a corresponding law.

This is shewn by measurements at the wide gap of the Susquehanna above Harrisburg, and is manifest to the eye in the bold notch called the Water Gap of the Delaware, where the strata that rise into the summit of the mountain on the New Jersey side of the river are thrown several hundred feet to the north of those in a corresponding position in Pennsylvania. I conceive these transverse dislocations to pervade all the great ridges and valleys of our Appalachian region and to be a primary cause of most, if not all, of those deep notches which are known by the name of Water Gaps, and which cleave so many of our high mountain ridges to their very bases.

An interesting generalization and one of some practical importance to the explorer for coal, especially in certain districts, is that which indicates that *all* the Anthracite Coal Measures of the several basins are but the several portions of *one* great formation, which previous to its elevation from beneath the waters in which its beds were deposited, constituted a single continuous mass of strata. I am led to this inference not merely from general views of geological causation in reference to all our formations, but after a careful comparison between the same parts of the series in each separate basin. Thus the lower coal measures of the Pottsville basin bear a striking resemblance to those in the same position in both the middle and northern coal fields, making proper abatement of course for the progressive changes discernible in all the strata when traced over extensive areas. I will not at present assume it as established, nor even suppose it susceptible of positive demonstration hereafter, that the great coal seam which lies near the base of the coal measures, commonly from the second to the fourth in position above the conglomerate, is one and the same stratum in all the several regions. Many facts however lend a high degree of probability to the conjecture. There being but one seam of such enormous magnitude in each basin, its occuring in the same part of the series, the close resemblance between its neighboring strata when we compare these in the several basins, and the exact identity of the vegetable fossils of the slates, and the want of this identity with those in the higher portions of the mass; all furnish ground for the belief, that this enormous stratum wherever it occurs, is but a remaining part of one originally more widely diffused deposit belonging to all the basins.

Like nearly all the other strata of the entire series of the formations in the quarter of Pennsylvania which embraces the anthracite coal, this seam, considering the thick bed in each basin as the same, decreases in thickness as we follow it toward the north and west. Thus at the great coal quarries called the Summit Mines of the Lehigh company, which are on a terrace on the side of the Sharp mountain, the depth of the deposit including its numerous layers of coal and alternating thin bands of slate is about fifty feet, while that of the corresponding bed on the north side of the same basin both at Pottsville and at the Nesquehoning mines is about twenty-eight feet. In the Beaver Meadow and Hazleton basins its average thickness is about twenty-two feet, which is very nearly that of the corresponding bed at Wilkesbarre and Carbondale in the northern basin. This shews an abatement in its thickness going northward, and making a similar comparison between its dimensions as we successively meet it passing from the east toward the west in each basin, we perceive a corresponding diminution in the thickness of the mass to take place in that direction also. Thus the thickness at Beaver Meadow somewhat exceeds that at the gap of the Little Mahonoy near the western extremity of the Shamokin basin, while the depth at Wilkesbarre surpasses that at Nanticoke.

In considering the large coal seam near the bottom of each series of our anthracite strata as belonging to a single stratum, I wish to explain, that I regard these several thick deposits as formed most usually, by the junction of two or more smaller beds brought together by the thinning out of the interposed layers of slate and sandstone. Thus observation renders it highly probable that the enormous bed of coal at the Summit Mines of the Lehigh company, owes its thickness of more than fifty feet to the coalescing of three or four of the thick and closely adjacent seams to be seen near the bottom of the formation at Tamaqua, about five miles further to the west. With this limitation of my meaning I conceive it probable that the main coal bed near the bottom of each set of coal measures occupies the same or an equivalent position in the strata in all the basins, and that a portion at least of the mass is identical, and was once continuous from one anthracite coal region to the others.

GENERAL OBSERVATIONS.

In taking a general review of the extensive series of our Appalachian formations, now for the first time systematically classified and described, our attention is forcibly arrested by their vast thickness, the immensity of their range, and the inexhaustible stores of mineral treasure which they contain.

From the base of the entire series, where the bottom of the lowest sandstone is in contact with the primary rocks of the South mountain, to the uppermost beds of the Anthracite coal measures, the absolute depth of this enormous group of strata in our counties east of the Susquehanna, cannot be less than *forty thousand feet*. It is worthy of remark, that probably no other district in the entire Appalachian chain, from the Hudson river, to Northern Alabama, presents our American lower secondary rocks on an equally expanded scale, or so admirably developed for Geological investigation.

The gigantic magnitude of the areas, covered by these thirteen formations, may be conceived, when I state that they not only occupy the entire surface of Pennsylvania, with the exception of the corner of the State, southeast of the South mountain, but that with a few interpolated strata, they comprise three-fifths of the territory of the United States, east of the Mississippi.

In an essay still unpublished, but written nearly a year since based in part upon my own personal observations, and in part upon a comparison between these and the numerous insulated descriptions of our rocks, given by various Geologists and travellers, I have attempted, and as I believe successfully, to trace individually, the formations of our great Pennsylvanian series, south westward along the mountains as far as Alabama, and also to identify them in their course across New-York, and the north-western States, and Canada, to the northern shores of Lake Huron and Lake Superior.

Within the whole of this wide expanse of country, researches will develope I conceive but *a single*, though vast group of strata, the successive sediments of one immense ocean, the creations of but one prolonged Geological epoch, commencing almost in the dawn of marine animal and vegetable existence, and terminating with the latest produced deposits of the coal.

Viewing the majestic scale of our formations, and the combined grandeur and simplicity of structure of the enormous Geological basin which they embrace, we turn with grateful satisfaction, to the peculiar position which Pennsylvania occupies, in this vast area. Lying on the margin of the great secondary basin of the United States, and traversed as it is, for nearly three hundred miles through its centre, by the whole broad beltof the Appalachian or Allegheny chain, in which a system of gigantic anticlinal elevations, brings the entire series of formations, several times in succession to the surface, it holds in combination with western Maryland, middle Virginia and eastern Tennessee, the *key* to the Geology of many of the other States, where but *a part* of the same strata are spread out in a nearly horizontal attitude, and exhibited in but a single belt. But it is especially fortunate as to the part of the Appalachian chain which it includes. Being at the termination of the great mountain axes, which have elevated the strata, it is to the gradual dying out of these undulations towards the north-east, that by preserving the upper deposits from the destructive agency which has swept them away, in the more disturbed portions of the chain, we possess our Anthracite Coal, one of the most inestimable of all the mineral treasures which nature has bequeathed us. The same Geographical position has placed us, in regard to the great basin, precisely where the general structure of the whole can be best observed, the upper rocks including the coal, not passing out of the State towards the northeast, but bending northward and then suddenly turning westward towards Ohio, at the same time that the middle members of this series sweep outside of these as far as the Mohawk, and returning, are recognized along our northern frontier, while those at the base of the formations are beheld encircling these again, and tracing a yet wider curve to run northwestwardly through Canada, and the region of the upper Lakes. We have thus a clue on the one hand, to nearly the whole Geology of the Appalachian chain south-westward as far as Alabama, and on the other, to that of the greater part of New-York, and the other regions to the northwest and west of us.

I conceive that much valuable information of a practical character will in the prosecution of the Geological Survey of this State, be derived by paying a vigilant regard to the progress of similar research in other States, the correspondence between whose strata and mineral deposits and our own is so striking. For in accordance with the views above adopted, that all the strata hitherto discovered in the great basin of the United States, above the primary rocks as high as the coal inclusive, constitute but a single group, of which we have the type in the Appalachian region of Pennsylvania developed to an extent nowhere equalled; it must be obvious that we may render subsidiary to our own researches, the explorations made and making in the same formations throughout any portion of the widely expanded area to which so large a part of our own Geology appertains.

But the most interesting of all the considerations connected with our geological position, is the magnificient picture it presents of our resources. Embracing a territory where the upper or coal bearing rocks of the great ancient secondary basin of the continent terminate toward the east and north, the revolutions which have stripped other States of those treasures, have left us in possession of some of the largest and most richly supplied coal fields of which any country can boast. When we regard their immense extent, comprising either the whole or a part of the area of thirty counties out of the fifty-four in the State, and the wide range and great thickness of many of the coal seams, and when we contemplate the amazing variety in the character of the mineral itself, shewing every known gradation from cannel coal to anthracite, fitting it thus for nearly every possible adaptation in the arts or as a fuel, and then turn our attention to the geological and topographical *structure* of the regions, affording a ready access to their most secluded districts, we behold such a prodigality of happy circumstances as may well inspire exultation. It is estimated that the anthracite coal conveyed to market from our mines in the course of the past year, has nearly amounted to Nine Hundred Thousand Tons, yet this large quantity sinks into insignificance when we look at what the coal trade even in the next ten years is destined to become. If we turn to the southern anthracite basin, the present seat of the most extensive mining operations in the State, we behold a mass of coal measures nearly sixty miles in length and two in average breadth, having in the middle an aggregate thickness of good and available coal exceeding probably *one hundred feet.* When we consider that from this basin and its branches, above 730,000 tons have been sent to market in the course of the past year from six districts only, the Nesquehoning, the Lehigh Summit, the Tamaqua, the Pottsville, the Pine Grove and the Wiconisco mines, and when we reflect that nearly all this coal has been taken from the strata above the water level below which hundreds, nay thousands of feet of coal, following the dip of the seams, lie still untouched, we are made aware of the enormous amount of undeveloped resources in this coal region alone. The valuable mines of Tamaqua, Pine Grove and Wioonisco are only waiting for greater facilities of access to the important markets on tide navigation on the Delaware and Chesapeake to augment by a large amount the annual supply.

The Beaver Meadow, Hazleton and contiguous basins bid fair from the quantity, quality and admirable position of their coal, to become also on a large scale successful contributors to our growing coal trade.

The inexhaustible possessions of the Mahonoy or Shamokin basin, one of the richest and largest of all the Anthracite coal fields of the State are hardly yet developed, but so soon as the contemplated outlets are completed, the resources of this single valley in which much f the coal is of very superior quality, will be acknowledged to form a most important item in the mineral wealth of Pennsylvania.

To all these deposits let us add the vast supplies of coal which fill the large and beautifully constructed basin of Wyoming and the Lackawanna. Here again, when we regard the excellence of the coal, its great abundance, and the admirable position of the region, with a choice of outlets and a boundless market toward the north, we are struck with astonishment at the prospect.

The awakening spirit of enterprise which is beginning to appreciate the riches of our numerous coal fields is also directing itself in part to the other great mineral staple of the State, our iron ore.

Few regions of similar extent in any country possess this invaluable mineral in the quantity and variety under which it exists in Pennsylvania. To say nothing of the abundance of the admirable pipe ores of our limestone valleys, or the equally profuse supply of rich argillaceous ore in the bituminous coal measures west of the Allegheny mountain, and viewing merely the numerous belts of the brown calcareous or fossiliferous ore of our Fifth Formation, what a picture of wealth does this alone present to stimulate to the cultivation of the useful manufacturing arts, the active industry of our citizens.

But it is when we consider our various kinds of ore and of coal, under one view, and dwell on their contiguity, their valuable adaptations to each other, and then their exhaustless abundance, that we acknowledge with what a lavish yet studious hand, nature has scattered these two great sources of power, prosperity and wealth through Pennsylvania.

CONCLUDING REMARKS.

In my first annual report I made allusion to the glaring defectiveness of the present State Map of Pennsylvania, drawing attention to the impediments which its gross errors place in the way of accurate geological investigation, and mentioning the impracticability of delineating, with any approach to truth, the boundaries of the strata and the position of their mineral deposits after research has ascertained them. In the parts of the State to which the examinations of the survey during the past year have been more particularly confined, the topography of the map appears to be especially erroneous, a fact to be the more lamented, as great advantages would arise to the anthracite regions of the State, were it practicable to exhibit upon the map an exact representation of the intricate features of this highly important division of our Geology.

Should the Legislature at some future day provide for the construction of an accurate Map of the State by instituting a Trigonometrical and Topographical Survey, the results would be fraught with extensive benefits to almost every branch of public and private enterprize, and would reflect lasting credit on the practical wisdom of Pennsylvania.

All which is respectfully submitted.

HENRY D. ROGERS.

PHILADELPHIA, January 27th, 1838.

GLOSSARY

GEOLOGICAL AND OTHER SCIENTIFIC TERMS EMPLOYED IN THIS REPORT.

EXTRACTED FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium. Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym. alluo*, to wash upon.

Anticlinal Axis. If a range of hills, or a valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Argillaceous. Clayey, composed of clay. *Etym. argilla*, clay.

Bitumen. Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym. bitumen*, pitch.

Bituminous Shale. An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Calcareous Rock. Limestone. *Etym. calx*, lime.

Calcareous Spar. Crystallized carbonate of lime.

Carbon. An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym. carbo*, coal.

Carbonate of Lime. Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water,—and all combinations of it with other substances are called *Carbonates.* All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carboniferous. A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous. *Etym. carbo,* coal, and *fero,* to bear.

Chert. A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Coal Formation. This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable. When the planes of one set of strata are generally parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or Puddingstone. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a silicious, calcareous, or argillaceous nature. *Etym. con,* together, *glomero,* to heap.

Crop Out. A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crystalline. The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble have a *crystalline* texture.—Sugar-candy and calcareous spar are crystallized.

Denudation. The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym. denudo,* to lay bare.

Diluvium. Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action of a diluvian wave or deluge sweeping over the surface of the earth. *Etym. diluvium*, deluge.

Dip. When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle of dip or inclination.

Encrini. (plural of encrinus) Marine animal bodies, having a long jointed stem, the joints somewhat resembling small buttons with a central perforation. These abound in the lower secondary rocks.

Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure, varying in width from a mere line to several feet, which is generally filled with broken stone, clay, &c.

Ferruginous. Anything containing iron. *Etym. Ferrum*, iron.

Formation. A group, whether of alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil. All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym. fossilis*, anything that may be dug out of the earth.

Gneiss. A stratified primary rock, composed of the same materials as granite, but having usually a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Gypsum, a mineral composed of lime and sulphuric acid, hence called also *sulphate* of *lime*. Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Plaster of Paris is a common term in this country for the white powder of which casts are made.

Laminæ. Latin for plates; used in geology, for the smaller layers of which a stratum is frequently composed.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite are mica. *Etym. mico*, to shine.

Organic Remains. The remains of animals and plants (*organized* bodies) found in a fossil state.

Oxide. The combination of a metal with oxygen; rust is oxide of iron.

Oxygen. One of the constituent parts of the air or the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Producta. An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites. (Iron.) A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral.

Quartz. A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone. Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Seams. Thin layers which separate two strata of greater magnitude.

Secondary Strata. An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Shale. A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.* German *schalen*, to peel, to split.

Shingle. The loose and completely water-worn gravel on the sea-shore.

Silex or Silica. The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth.

Silicious. Of or belonging to the earth of flint. *Etym. silex*, which see. A silicious rock is one mainly composed of silex.

Stalactite. When water holding lime in solution deposits it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called *stalactites.*

Stalagmite. When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone: such a crust is called *stalagmite*, in opposition to *stalactite*, which see.

Strata, Stratum. When several rocks lie like the leaves of a book, one upon another, each individual forms a *stratum*;—strata is the plural of the word. *Etym. stratum*, part of a Latin verb, signifying to strew or lay out.

Strike. The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Synclinal Axis. When the strata dip in opposite directions *towards* a common central imaginary line, it is called a synclinal line or axis.

Thin out. When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Zoophytes. Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. From two Greek words signifying animal and plant.

ERRATA

Page 17, seventh line from bottom, for "attained" read "*ascertained.*"

Page 35, nineteenth line from bottom, for "when" read "*whence.*"

Page 54, first line in fourth paragraph, for "Appalachian" read "*Apollacan.*"